

*Manual of*

**EXPLOSIVES**

**MILITARY PYROTECHNICS**

**CHEMICAL WARFARE AGENTS**

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EXPLOSIVES, MILITARY PYROTECHNICS

*and* CHEMICAL WARFARE AGENTS



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**EXPLOSIVES**

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*and*

**CHEMICAL WARFARE AGENTS**

*Composition · Properties · Uses*

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To  
My Daughters  
Yvonne and Margaret

*Who have done all the typing and secretarial work in the preparation of the manuscript. Their unfailing diligence, patience, and all around helpfulness have made the writing of this book a pleasant task.*



## Preface

It is the chief aim of this book to be of service to scientific and technical workers in the field of explosives and war chemicals and to students who are beginning to specialize in these subjects. In preparing for Engineers' Defense Training Courses in "The Chemistry of Powders and Explosives," the author recognized the need for a book of this sort.

The nomenclature in the field of explosives and war chemicals is perplexing. Most of the chief explosives are known under many different names and designations, including the correct chemical name, chemical synonyms, American and foreign trade names, and warfare symbols. In literature on the subject sometimes one term is used, and sometimes another. Unless one knows the meaning of all of the terms, it is often necessary to make a search for information; and this, in the literature on explosives, is a time-consuming procedure. For instance, in a technical article on detonators, a chemist may find a reference to Dinol. He knows this is a trade name; and if he does not know the chemical composition of the product and wishes to find it out, he has to know its correct chemical name. He may spend quite a bit of time before he establishes the fact that Dinol is the commercial term for dinitrodiazophenol.

Or, in a scientific journal, a chemist may see a reference to the exceptionally high rate of detonation of cyclotrimethylenetrinitramine. If he wishes to know if this product is made and used under some trade name, how much time will he spend before he finds out that it is "Cyclonite" for which he has been looking?

For the purpose of providing information of this sort quickly, the author started to assemble a dictionary of explosives and explosive mixtures, including all of the various

terms with cross references. This arrangement was found to be very useful and time-saving; and it was later extended to include some of the physical and chemical properties, particularly those which are of significance in connection with the application of the products as explosives. The final interest to the worker in this field is the use of these explosives for industrial and military purposes. Explosives are often used in different forms and mixtures for various and specific effects, and here again the information is scattered. It was therefore decided to expand the dictionary to a manual comprising composition, properties, and uses of industrial and military explosives and explosive mixtures. The list also includes all other chemicals and modifying agents which may be present in explosives and in ammunition, but it does not include raw materials which are used to manufacture these products. This arrangement makes it possible to find out quickly why and where certain chemicals find application in the field of explosives for such purposes as deterrents, oxidizers, binding agents, fusion- and flash-point depressants, cooling agents, fuel components, gelatinizers, rust-preventing and coating agents, lubricants, absorbents, etc.

With no claim for completeness, an earnest effort has been made to list all of the more important explosives, explosive mixtures, modifying and addition agents, and particularly those which are actually being used or which have been used as far back as World War I. Some of the older explosives and compositions have also been included in order to give a picture of the gradual development of the field or because they are of particular historic interest.

Military pyrotechnics are closely connected with the field of military explosives; they are used in many special types of ammunition and munition and also in such devices as flares, rockets, and smoke pots. With the tremendous development of the military air forces the importance of obscuring smokes and incendiary activities has been greatly

enhanced. Hence it was considered appropriate to include in this manual all of the more important chemicals which are finding application as pyrotechnics, incendiaries, and smoke-producing agents.

Finally, in view of the renewed intense interest in chemical warfare agents, this group of chemicals, which may again become of vital significance, has also been included in the book. Hundreds of products have been proposed as toxic or irritant chemical agents, and a considerable number have been put to the test during World War I. As a result only a few dozen of those used are still considered to be generally effective and suitable to application under combat conditions. It is mainly the latter group which is included in the manual. A few chemical agents have been listed as being of historic interest, and some others which have not been tried in battle but which are generally expected to be very effective.

In this connection it seems appropriate to make some comments in respect to confidential information. Ordnance, Chemical Warfare Service, and other government laboratories have no doubt accumulated a large amount of information which is not generally known and which is considered confidential. Munition and explosives plants also have certain process and manufacturing features which are secret. The author thoroughly recognized the importance of this matter, particularly at this time, and he has been extremely careful not to publish any information whatsoever which might be considered to be confidential. He therefore has limited himself to subjects and data for which there is reference in generally available literature, which can be found in the quoted Bibliography.

For the convenience of the reader the Bibliography has been subdivided into several groups: books, bulletins and manuals, catalogues, articles in periodicals, and patents. It comprises principally the publications which have been used in the preparation of this manual. The list of books on ex-

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plosives is very small but fairly complete, indicating the dearth of comprehensive literature on this subject in the English language. As a matter of fact only one modern text is available, the excellent publication of Professor Tenney L. Davis, *The Chemistry of Powder and Explosives*, Vol. 1, 1941, comprising properties of explosives, black powder, pyrotechnics, and aromatic nitro compounds. A second volume is expected to cover nitric esters, smokeless powder, dynamite and other high explosives, ammonium nitrate, and nitroamines. I wish to make grateful acknowledgment for the valuable assistance which has been afforded in the preparation of this manual through the publication of Dr. Davis' most useful and welcome book.

In the field of chemical warfare agents we have fortunately one modern comprehensive text which covers the subject most thoroughly and effectively, namely, *Chemicals in War, a Treatise on Chemical Warfare* (published in 1937), by Lt. Col. Augustin M. Prentiss. Grateful acknowledgment is also made to this publication as having been the main source of information on war gases and smoke-producing and incendiary agents. As a check-up in European experience on toxic agents, the book on *Chemical Warfare* by Curt Wachtel has also been very helpful.

In the group of "Bulletins and Manuals" the literature is extensive; only few have been quoted. For further references attention is called to the list of publications of the U. S. Bureau of Mines, which can be secured from the Superintendent of Documents, Washington, D. C.

The literature on explosives in scientific and technical journals is overwhelming, and the numbers of patents issued annually throughout the world are legion. The references in the Bibliography have been limited mostly to publications which have appeared within the last fifteen years and particularly to those which served to illustrate certain points raised in the text or some important developments in the explosives field.

No doubt a great many other significant publications could have been found which would have led to a further expansion of the manual. However, rather than to strive for perfection it was considered more important to bring the manual to completion and to publish it now. In the present emergency, time is of paramount importance, and the author hopes that this book will not only be a time-saver but that it will be of service generally to the professional men who are concerned with explosives and particularly to the thousands of new workers who are entering this field.

Many thanks are due to Mr. Louis Frederic Du Bois for reading the entire proof with the author.

Comments from readers regarding additions, corrections, or improvements will be most welcome.

J. B.

ST. LOUIS, MO.  
December, 1942



## Nomenclature, Arrangement, and Abbreviations

For the purpose of quick reference the articles in the manual have been arranged in alphabetical order. Products which are definite chemical compounds are listed and discussed under their correct chemical names. If they are also known by chemical synonyms, trade names, or service symbols, these will be found as cross references to the chemical term. A few exceptions have been made, however. In the explosives field, for instance, the name *nitroglycerine* has been adopted by tradition for general use, rather than the correct chemical name of *glyceryl nitrate*. Therefore, the article will be found under *nitroglycerine*. Similarly, the name *nitrocellulose* is thoroughly established, and the correct term *cellulose nitrate* is mostly limited to scientific publications. In this case an article is written under both names, but in the text the term *nitrocellulose* is used throughout.

Further, in the group of chemical warfare agents the products are listed under the names which have been adopted by the Chemical Warfare Service. These names may or may not be identical with the modern terms of chemical nomenclature. An example of this would be *phenacyl chloride*. *Phenacyl chloride* is the correct name, but the chemical warfare agencies of all countries use the chemical synonym *chloracetophenone*, under which the product is more generally known; and this is the term under which it is listed in this manual.

This brings up still another point. Even if the article is written under *chloracetophenone*, the modern chemical spelling would be *chloroacetophenone*. However, since the term *chloracetophenone* is official in the service and since this book is of a technical rather than of a scientific nature, it seemed

to be in order to list the chlorine and bromine derivatives under the official names. The chloro- and bromo- terms will be found under cross references. Generally, nomenclature and spelling follow the rules of the American Chemical Society, as used in *Chemical Abstracts*, with the exceptions stated above.

Symbols usually refer to U. S. and Chemical Warfare designations; for some of the more important explosives and warfare agents some of the foreign symbols are also listed.

Explosive mixtures which are known only under a trade name are, of course, found under the latter; but cross reference is usually made to the group of explosives to which they belong.

The arrangement of the Bibliography has already been referred to in the Preface. Many of the data of the manual have been obtained from books, and it would not be feasible to give a reference for every item. Moreover, much of the information given can be found in several of the quoted books. However, quite a number of statements made in the manual contain references to articles in periodicals or to recent patents which have been listed in the Bibliography. References to journal articles are designated by a numeral, and to patents by the letter *P* and a numeral.

Abbreviations: All temperatures are given in degrees C; therefore the C has been omitted in temperature readings. As far as available, specific gravities are designated at definite temperatures. Vapor densities are always stated in comparison to vapor density of air = 1.

d. = density  
Sp. gr. = specific gravity  
M. P. = melting point  
B. P. = boiling point  
m. = meter  
mg. = milligram

mm. = millimeter  
sec. = second  
H. E. = high explosive  
L. E. = low explosive  
NH = non-hygroscopic  
FNH = flashless non-hygroscopic



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## Introduction

Explosives being chemicals of various sorts and the explosive industry being essentially a chemical industry, it is obvious that the development of the explosive field is closely related to progress in chemistry and chemical technology. This will be evident from reading the articles on some of the main explosives described in this manual. However, on account of the particular arrangement of the latter in alphabetical order this interrelationship is not shown in continuity or in chronological order. As an introduction to the manual it therefore seemed appropriate to present briefly the development of the various types of explosives in relation to chemical progress and discoveries and in connection with the availability of raw materials and new industrial processes.

On account of this relationship it is not surprising that for a period of about five centuries there was practically only one explosive known and used and that there was little progress in the field. This explosive of course was gunpowder, used first as a propellant and later also for blasting purposes. The gradual improvement consisted mainly in the production of purer and more uniform raw materials, in the perfection of manufacturing methods, and in the production of the powder in various grain sizes suitable for numerous uses and weapons.

During most of this period (1300–1800) chemistry was but little developed as a science. The manufacture of gunpowder was an empirical procedure, and its nature as an explosive was not understood. It was only towards the end of the eighteenth century that the discovery of oxygen by Priestley and the studies of Cavendish and Lavoisier on air and combustion began to provide a scientific basis for

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the chemistry of explosives. During the early part of the nineteenth century this foundation was further strengthened by the brilliant studies of Gay-Lussac, Dalton, and Avogadro on the chemical and physical nature of gases and on their behavior under the influence of heat and pressure.

The year 1800 marks the entrance of organic chemicals into the explosive field with the discovery of mercury fulminate by Howard, followed by the chemical investigation of the fulminates by Liebig. The use of mercury fulminate as a primary explosive developed very slowly, and it was only generally adopted for military purposes in the latter part of the nineteenth century, simultaneously with the introduction of improved guns and rifles.

Up to about 1850 gunpowder was still unchallenged in its position as the only industrial and military explosive. Moreover, around this time, manufacture of gunpowder was facilitated through the availability of Chile saltpeter as a raw material for making potassium nitrate. However, the ground was being prepared for powerful competition and new developments through the rapid rise of organic and physical chemistry. As a result, some of the greatest discoveries and inventions in the explosive field were made during this period. The milestones in this march of progress are nitroglycerine, dynamite, blasting gelatine, ammonia dynamite and ammonia gelatine, guncotton, pyrocotton, and smokeless powder. All of these products, with some modifications, are still standard explosives today. The manufacture of each of them requires nitric acid.

Discovery of the sodium nitrate deposits in Chile provided the raw material for nitric acid manufacture and was a great factor in the large-scale production of these new explosives.

By treating cotton with concentrated nitric acid, Pelouze in 1838 obtained a product which exploded on percussion. Schoenbein discovered in 1845 that the nitration of cellu-

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lose takes place much more easily and completely by means of a mixture of concentrated nitric and sulfuric acids. This marks the beginning of the general use of mixed acid for nitration purposes. In 1846 Sobrero made use of the same method for the first preparation of nitroglycerine. Two new explosives were now in the field which were ever so much more powerful than black powder.

Manufacture and storage of nitrocellulose resulted in many disastrous explosions. In 1865 Abel mastered the technique of safe manufacture and satisfactory keeping qualities of the nitrocellulose. Twenty years later, in 1886, Vieille produced the first smokeless powder from nitrocellulose by colloidizing it with a mixture of ether and alcohol; this was the beginning of the end of gunpowder as a propellant.

Nitroglycerine was at once recognized as a very powerful high explosive, but it was soon found to be too sensitive to be used by itself. Twenty years after its discovery, it was Nobel, the greatest inventive genius in the explosive field, who harnessed the explosive energy of nitroglycerine by absorbing it in kieselguhr. In this manner he made it safe for handling and transportation. At the same time he invented a safe and effective way of initiating the detonation of this new explosive, which he called dynamite, by means of a mercury fulminate detonator. Moreover, by gelatinizing the nitroglycerine with nitrocellulose he invented blasting gelatine, the most powerful blasting explosive. Nobel also introduced ammonium nitrate in the explosive field, and by combining it with dynamite he laid the foundation for the so-called safety and permissible ammonia dynamites.

During this classical period of inventions and discoveries in the field of explosives a simultaneous and equally important development took place in the science of explosives. A group of physical chemists, under the leadership of Berthelot, investigated the thermochemistry of explosives and explosions; and Vieille, Mettengang, and Dautriche devel-



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oped methods for measuring the velocity of detonations and projectiles.

In the latter part of the nineteenth century new raw materials for the chemical industries became available from city gas and by-product coke oven operations. Benzene, toluene, xylene, naphthalene, phenol, cresols, and xylenols served as crudes for conversion to various intermediates used in the growing new synthetic dyestuff industry. Many of these intermediates and finished products were nitro compounds and found their way into the explosive industry.

Picric acid, trinitrophenol, was used for some time as a dyestuff before it was found to be also a powerful explosive. It was first adopted as a military high explosive by the French Government in 1886. Nitro derivatives of benzene and toluene found application as ingredients of blasting explosives. In the beginning of the twentieth century trinitrotoluene was adopted as a bursting charge for shells. Besides picric acid it was generally and extensively used as a bursting charge during World War I.

Quite a number of other high explosives were introduced during this period; nitro derivatives of aniline, anisole, diphenylamine, cresols, xylenols, etc. Some of these were used as bursting charges and some as boosters, the outstanding representative of the booster explosives being trinitrophenylmethylnitramine (Tetryl).

The manufacture of smokeless powder and high explosives required tremendous quantities of mixed acid. General introduction of the contact process for making sulfuric acid provided a convenient method for the production of highly concentrated and fuming sulfuric acid and greatly facilitated nitration operations. Nitric acid was generally produced from Chile saltpeter except in Germany, where towards the end of the war the nitric acid was obtained by air oxidation of synthetic ammonia. This process and its modifications have in the meantime revolutionized nitric acid manufacture in the explosive industry of all countries.

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During the past twenty years much progress has been made in various ways. New very powerful high explosives have been developed, such as Penthrite and Cyclonite.

Mercury fulminate has no longer a monopoly as a primer. In some of its uses it has been replaced by azides, particularly lead azide; in some others chlorate primers have taken its place. Chlorates and perchlorates are also being used in industrial explosives and can now be readily manufactured by means of electrochemical processes.

New sources of raw materials for explosive manufacture have been made available from acetylene and from natural gas and petroleum products. In TNT manufacture, for instance, we no longer depend solely on toluene from coking operations. Even greater quantities are being provided by the petroleum industry.

Much progress has been made in the development of permissible and other blasting explosives. They are now "tailor-made" and based on scientific principles. Dozens of types of dynamites and dozens of grades of each type are manufactured in order best to fit any one of the many specific uses.

It is not the purpose of this book to discuss the chemistry of explosives. However, a few general and elementary statements seem to be in order as a guide for better understanding of this manual.

With the exception of a few azides and acetylides, which find use as initiators, most explosives contain oxygen and oxidizable elements. Oxygen is usually present in the form of labile radicals such as the nitric acid radical  $-\text{ONO}_2$  or the nitro group  $-\text{NO}_2$ . Such groups are characteristic for explosives, and they are called explosophore groups. Other oxygen-containing explosophore groups are the chlorate radical  $-\text{ClO}_3$ , the perchlorate radical  $-\text{ClO}_4$ , the fulminate radical  $-\text{ONC}$ , and the nitramine group  $-\text{NHNO}_2$ . The inorganic nitrates (potassium, sodium, ammonium, barium) are used as components of explosive mixtures in

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combination with oxidizable materials such as charcoal, sulfur in elementary or combined form, nitro compounds having insufficient oxygen for complete combustion, metals, metal alloys (such as silicides), etc. The organic nitrates (nitrocellulose, nitroglycerine, nitrostarch) contain the oxygen and the oxidizable elements carbon and hydrogen within the same molecule; they are self-contained explosives. The same is true for the aromatic nitro explosives (trinitrotoluene, trinitrophenol). Some explosives, like nitroglycerine and ammonium nitrate, have an excess of oxygen; others, like trinitrotoluene, have not a sufficient amount of oxygen for oxidation of the oxidizable elements which are present. A negative oxygen balance can be corrected by addition of substances which have an excess of oxygen, such as ammonium nitrate.

In the explosion of nitrate and nitro explosives nitrogen is set free in the elementary form, and the oxygen combines with the oxidizable elements, forming great volumes of gases ( $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ ) and a large amount of heat. All explosion reactions are highly exothermic. Those hot gases occupy a volume 10,000 to 15,000 times as large as the volume of the exploded material. The temperature of the explosion may be  $3000^\circ \text{C}$  and over. When metals are present in explosives, the heat of formation of the metal oxides contributes to further expansion of the hot gases.

Some explosophore groups, as for instance the azide group  $-\text{N}_3$ , contain no oxygen. In the explosion of lead azide the only explosion gas is nitrogen. A few explosives, the acetylides particularly, contain neither oxygen nor nitrogen. In this case the explosion is simply a heat effect. Heat of explosion, maximum temperature of explosion, volume of explosion products, and pressure developed in a closed chamber are the chief factors related to the total energy of an explosive. The effectiveness of an explosive, however, is primarily dependent upon the rate at which its energy is liberated. The rate of detonation of a high explo-

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sive is a measure of its brisance and is therefore of great significance. Velocity of detonation of high explosives includes the range of about 2000–8000 m/sec.

The above-mentioned characteristics of explosives are of basic importance. There are others, which are also of great significance, such as sensitivity to heat, friction, and impact, stability, and intensity of initial impulse required. A thorough knowledge of those properties is necessary to determine where and how any particular explosive may be used. These properties are functional rather than absolute. They may vary, for instance, with the physical form of the explosive, such as crystal form, crystal length, particle size, density, etc. This indicates, of course, the great importance of uniformity of the physical as well as of the chemical properties of explosives. Finally, we should keep in mind that it is feasible to adjust the explosive properties not only by variation of physical form and chemical composition but also by the use of modifying agents incorporated into the explosives or applied as coatings.

The following chronology will serve as a review of the statements made in the Introduction. The events listed in the chronology are by no means of equal importance. They include revolutionary discoveries and inventions as well as advances made from year to year. The chronology is intended to present a bird's-eye view of developments and trends in the explosive industry and of their relationship with advances in the science of chemistry and explosives.

### Chronology

1250

and earlier    Black powder used by Arabs, Hindus, and Chinese, particularly for pyrotechnic purposes.

1270

Black powder mentioned by Roger Bacon.

1328

Black powder described by Berthold Schwarz.

1346

Black powder (gunpowder) used in the battle of Crécy as propellant in wooden cannon.

1425

First record of graining or granulating gunpowder.

- 1435 First powder-stamp mill in Nürnberg.
- 1525 Classification of powder grains by screening reported in France.
- 1540 Large-grain powder base adopted for cannon.
- 1696 First blasting operations with black powder, Albula Road, Switzerland.
- 1800 Fulminate of mercury discovered and described by E. Howard in England.
- 1804 E. I. du Pont de Nemours Co. produced its first run of powder at Wilmington, Delaware.
- 1814 J. Shaw, Philadelphia, devised a steel cap filled with mercury fulminate.
- 1816 Copper cap filled with mercury fulminate came to be used.
- 1831 Bickford patented a safety fuse for use on land or under water. "Bickford Fuse."
- 1833 Pelouze prepared the first nitrocellulose by treating cotton with nitric acid.
- 1836 Pinfire breech-loading shotgun in France.
- 1841 Needle gun adopted in Germany with disk of fulminate on inside of base.
- 1845 Schoenbein nitrated cellulose with a mixture of nitric acid and sulfuric acid and started the promotion of nitrocellulose as a military explosive.
- 1847 Sobrero discovered nitroglycerine.
- 1847 Plant explosion in England in connection with manufacture of nitrocellulose.
- 1855 Von Lenk, Austria, introduced boiling in the nitrocellulose manufacturing process for the purpose of stabilization.
- 1860 Rodman, U. S. Army, discovered the principle of the progressive combustion of gunpowder and proposed perforated grains in prismatic form.
- 1863 Potassium nitrate made from Chile saltpeter.
- 1864 Abel, England, introduced intermittent boiling and pulping in the nitrocellulose manufacturing process for the purpose of stabilization.
- 1865 Nobel discovered that nitroglycerine could be made

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- to detonate by the explosion of a very small quantity of mercury fulminate.
- 1866 Nobel found that liquid nitroglycerine when absorbed in kieselguhr could be packed conveniently and safely into paper cartridges. Discovery of Guhrdynamite.
- 1867 Ohlssen and Norrbm patented a mixture of ammonium nitrate and charcoal or other carbonaceous material as an explosive.
- 1867 First Swedish and British Nobel patents on dynamites.
- 1867 Trauzl and Abel proposed a dynamite with an active base consisting of guncotton and charcoal for absorption of the nitroglycerine.
- 1873-77 Sprengel and Turpin introduced nitrated hydrocarbons as explosives.
- 1875 Nobel invented and patented blasting gelatine, one of the most outstanding developments in the explosive field.
- 1876 Nobel patented low-freezing dynamites.
- 1877 Trinitrophenylmethylnitramine (Tetryl) first obtained by Mertens.
- 1879 Nobel patented ammonogelatine-dynamite, using ammonium nitrate.
- 1883 Von Romburgh determined constitution of trinitrophenylmethylnitramine (Tetryl).
- 1884 Petri, Fallenstein, and Duren patented chlorate explosives for blasting purposes.
- 1884-5 Vieille, investigations on gelatinized nitrocellulose.
- 1884-89 Berthelot, Sarrau, and Vieille investigated the explosive properties of nitromannite.
- 1886 Picric acid adopted by the French Government as a high explosive under the name of Melinite.
- 1886 Vieille produced the first satisfactory smokeless powder from nitrocellulose by colloidizing it with ether and alcohol.
- 1887 Müller patented the first safety explosives.

- 1888 Nobel patented a double-base propellant produced by gelatinizing nitroglycerine with nitrocellulose.
- 1888 Use of ammonium picrate as an explosive patented by Nobel.
- 1889 Abel and Deware patented a double-base powder (Cordite) composed of nitrocellulose and nitroglycerine, colloided with acetone.
- 1890 Mendeleeff, investigations on nitrocellulose which established definite procedure for manufacture of pyrocellulose.
- 1891 Berthelot made the first determinations of velocities of detonation.
- 1891 Lead azide first prepared by Curtius.
- 1891 Trinitrotoluene used in industrial explosives.
- 1893 Will and Lenze investigated lead azide as a military explosive.
- 1893 Munroe patented for U. S. A. a powder called "Indurite" composed of guncotton colloided with nitrobenzene.
- 1893 "Pyro" manufacture on large scale in Russia.
- 1893 Maxim and Schupphaus developed perforated black powder grain and the subsequent perforated prismatic cocoa powder.
- 1894 Pentaerythritol tetranitrate proposed as an addition to smokeless powder (German patent).
- 1895-1909 U. S. Army used double-base powder for small arms.
- 1897 Linde introduced "Oxyliquit," the first explosive of liquid-oxygen type, prepared from charcoal saturated with liquid air and enclosed in an insulating paper wrapper.
- 1897 Beranadou, U. S. Navy, patented a powder of uniformly nitrated cellulose (about 12.45 per cent N) colloided with ether-alcohol.
- 1899 First important use of "Oxyliquit" in driving the Simplon Tunnel in Switzerland.
- 1901 First use of ammonium picrate in American artillery, introduced by Dunn.
- 1902 TNT used in Germany for filling shells.

- 1903 Nitrostarch manufactured by the Trojan Powder Co.
- 1904 German patent for use of glycol dinitrate to lower freezing point of nitroglycerine.
- 1904 TNT adopted in U. S. A. for military purposes.
- 1906 Dautriche introduced a simplified method for determination of velocities of detonation.
- 1908 Diphenylamine generally adopted as a stabilizer for nitrocellulose and smokeless powder.
- 1909 U. S. Bureau of Mines erected a testing gallery and established standards for permissible explosives.
- 1909 U. S. Army adopted a single-base powder.
- 1910 The French Explosives Commission recommends substitution of dinitroglycol for 1/8 of the nitroglycerine in authorized nitroglycerine blasting explosives to render the latter nonfreezing.
- 1912 Pentaerythritol tetranitrate proposed as a component of blasting-cap compositions (German patent).
- 1913 Claessen patented tetranitroanisole as an explosive.
- 1913 Vergé patented low-freezing dynamites containing liquid aromatic nitro compounds.
- 1913 Hartmann patented hexanitrodiphenyl sulfide as an explosive.
- 1914 Woodbury patented a means of varying the velocity of detonation of explosives containing ammonium nitrate by using large grains of ammonium nitrate when it is desired to make a mixture of low velocity of detonation and smaller grains when a higher velocity of detonation is desired.
- 1915 Wöhler patented a detonator mixture of lead azide with three parts mercury fulminate, which mixture does not become "dead pressed" even when subjected to 2000 atm. pressure.
- 1916 Calvert patented a mixture of copper thiocyanate or lead thiocyanate with potassium chlorate or potassium perchlorate as a detonating explosive for charging primers.
- 1916 Runge patented a detonator composed of TNT or other explosive not detonated directly by flame from



- a fuse, with an overlying detonating mixture containing chiefly lead azide.
- 1916 Gin patented cyanimides or their derivatives rich in nitrogen, mixed with substances yielding oxygen, such as ammonium nitrate and ammonium chromate.
- 1916 Nobel's Explosives Co., Ltd., patented an explosive for ballistic purposes from nitrocellulose and nitroglycerine with the aid of nonvolatile gelatinizing substances.
- 1916 Sprengstoff Akt.-Ges. patented Hexanitrodiphenyl as an explosive.
- 1917 Perchlorate Safety Explosives, Ltd., patented an ammonium perchlorate explosive containing finely divided zinc and combustible materials.
- 1917 Sadtler patented and produced nitrostarch and proposed it as a substitute for nitroglycerine in blasting explosives.
- 1918 Matter patented detonators made by using pentaerythritol tetranitrate in conjunction with a detonating substance.
- 1918 Canadian Explosives, Ltd., patented use of hexanitrodiphenyl sulfide in making cap compositions for primers.
- 1920 Eschbach patented priming compositions made by mixing lead azide with lead trinitroresorcinate.
- 1920 Marshall investigated the explosive properties of hexanitrodiphenylamine.
- 1921 Woodbridge patented surface coating of smokeless-powder grains with dialkyldiaryurea.
- 1922 Rintoul and Cross patented gelatinized blasting explosives with small amounts of accelerants for gelatinization (urethans, anilides, substituted ureas).
- 1923 Shilling patented a propellant explosive powder containing nitrocellulose and nitroguanidine, superficially impregnated with a deterrent material such as dinitrotoluene.
- 1924 Harle patented a primer of lead azide desensitized with 12-14 per cent paraffin.

- 1924 Fidler patented a flashless propellant explosive formed of nitrocellulose, starch, and dinitrotoluene.
- 1925 Grotta patented compound detonators with a priming charge formed of mercury fulminate, a heavy-metal azide, and a secondary charge formed of a mixture of equal amounts of Tetryl and potassium chlorate.
- 1925 Brown patented nitroguanidine as a sensitizer in various perchlorate explosives.
- 1926 Swint patented a low-density dynamite containing nitroglycerine (7-15 per cent) and finely divided balsa wood (5-15 per cent) used with ammonium and sodium nitrate.
- 1926 Rathsburg patented an explosive primer composition of guanylnitrosaminoguanilyltetrazene with chlorates, nitrates, peroxides, etc.
- 1926 Franklin patented a nitrocellulose powder containing nitroguanidine and an oxidizing agent such as barium nitrate, and superficially impregnated with a deterrent material such as dinitrotoluene.
- 1927 Du Pont Co. patented a flashless cannon powder of colloided nitrocellulose containing grains of a mixture composed of charcoal and a nitrate.
- 1927 Swint patented a low-velocity, low-density dynamite consisting of 50-80 per cent coarse ammonium nitrate, bagasse pith, and 7-15 per cent of a liquid explosive ingredient.
- 1928 Naoum patented a pourable explosive obtained by mixing pentaerythritol tetranitrate (at least 50 per cent) and aromatic nitro compounds, especially TNT.
- 1929 Wyler patented an explosive composed of ammonium nitrate and hexamethylenetetramine, with or without nitrostarch, sodium nitrate, zinc oxide, hydrocarbon oil.
- 1929 Pritham patented pyrotechnic or projectile tracer ammunition containing salts of thorium and cerium, such as the nitrates, used with calcium resinate as a

- binder, and with or without magnesium and strontium nitrate.
- 1929 McNutt patented a noncorrosive priming composition composed of mercury fulminate, a metal dioxide (barium peroxide), and a silicide such as that of calcium.
- 1929 Nobel and Co. patented ethanolamine nitrates as explosives.
- 1929 Stettbacher proposed a mixture of 80 per cent Penthrit and 20 per cent nitroglycerine under the name of Penthrinit as explosive for industrial and military uses.
- 1931 Snelling patented propellant powder grains formed by compressing nitrostarch granules rendered smokeless and flashless by admixture with guanidine nitrate, ammonium nitrate, urea nitrate, or nitroguanidine, and superficially colloided.
- 1931 Werme patented a propellant powder in which lead dust is intermixed in a quantity sufficient to form a corrosion-preventing coating in the bore of the gun.
- 1931 Boyd patented an explosive containing nitrated glycerol and nitrated sugar.
- 1932 Stettbacher patented a high explosive composed of pentaerythritol tetranitrate and nitroglycerine together with a small proportion of collodion cotton.
- 1932 Naoum patented a blasting explosive composed of calcium nitrate and nitroglycerine, with or without addition of charcoal, sawdust, or TNT.
- 1932 Crater patented nitroinositol as an explosive.
- 1933 Clark investigated the preparation and explosive properties of trinitrophenylnitraminoethylnitrate (Pentryl).
- 1933 Crater patented inulin nitrate as an explosive.
- 1933-41 Olsen patented simplified process for stabilizing and gelatinizing nitrocellulose powder and for producing it in spherical form, with or without deterrents, coatings, and other modifying agents.

- 1934 Clark investigated the preparation and explosive properties of hexanitrodiphenylaminoethylnitrate.
- 1935 Johnson and Lewis patented a pulverulent dynamite.
- 1935 "Nitramon" introduced by the du Pont Co., "the safest blasting agent available."
- 1939 Crater patented a guanidine nitrate blasting explosive.
- 1941 Von Herz patented explosives for explosion rivets.
- 1941 Allison patented a smokeless powder the grains of which are coated with phthalide, which serves as a deterrent.
- 1941 Roth investigated mixtures of tetranitromethane and nitrobenzene.
- 1941 Wyler patented trimethylolnitromethane for use in explosives.
- 1942 Allen patented an explosive device containing a shattering charge and two liquefied gases capable of explosive combination when intermingled.
- 1942 Quantity production of ball powder (Western Cartridge Co.) for small arms ammunition.
- 1942 Friederich patented tetrazylazides as disruptive explosives.
- 1942 Denués patented liquid oxygen explosives containing phosphoric acid as fire retardant.
- 1942 Tetrytol, a mixture of TNT and Tetryl, adopted as a military high explosive.



# Explosives, Military Pyrotechnics and Chemical Warfare Agents

## ABBCITE

*Composition:* An ammonia dynamite containing a relatively large amount of an alkali chloride.

	PER CENT
Ammonium nitrate . . . . .	58
Nitroglycerine . . . . .	8
Dinitrotoluene . . . . .	2
Sodium chloride . . . . .	23
Wood meal. . . . .	9

*Properties:* This is an example of explosive mixtures in which sodium chloride has been incorporated for the purpose of reducing brisance and heat of detonation in order to reduce the risk of fire-damp explosions.

*Uses:* As blasting explosive in coal mining.  
See Ammonia Dynamite, Permissible Explosives.

## ACARDITE

Technical term for diphenylurea (See).

## ACTIVATED CHARCOAL (ACTIVE CARBON)

*Composition:* A more or less pure form of carbon characterized by a high adsorptive capacity. The chemical composition varies with the source.

*Properties:* The true density of active carbon, when free from tarry matters and other impurities, is approximately 2.1; the apparent density varies, depending on the source and treatment.

*Uses:* In granular form and in combination with soda lime as gas-mask canister filling. Only chars of considerable density, specially prepared for such uses, are suitable for gas masks.<sup>9\*</sup>

See Soda Lime.

## ADAMSITE

A chemical warfare agent named after Roger Adams, its American discoverer.

See Diphenylaminechlorarsine.

## AJAX POWDER

*Composition:* A representative of the earlier permissible dynamites, used particularly in England and containing ammonium oxalate as a cooling agent. Composed of wood flour, potassium perchlorate, nitroglycerine, ammonium oxalate, and small quantities of collodion cotton and nitrotoluenes. For properties and uses, see Permissible Dynamites.

## ALPHA-NITRONAPHTHALENE

See Nitronaphthalene.

## ALPHA-TRINITROTOLUENE

Chemical name for TNT.

See Trinitrotoluene.

## ALUMINUM, FLAKES OR POWDER

*Symbol:* Al

*Properties:* Light, malleable, and ductile metal with good resistance to corrosion. Sp. gr. 2.705 at 20°. M. P. 659°.† B. P. about 1800°. Soluble in hydrochloric

\* Numerals refer to articles quoted in the bibliography, section "Articles in Periodicals."

† All temperatures are given in degree Celsius, therefore the letter C has been omitted.

acid, sulfuric acid, and caustic alkalies. When ignited in mixture with strong oxidizing agents, such as nitrates, chlorates, or perchlorates, aluminum powder burns with great heat and with an intensely bright light.

*Uses:* The fine powder is used as component of explosive mixtures and primer compositions, in flares and various other pyrotechnic devices. The coarse powder is used in incendiary bombs. Aluminum flakes are also used as an ingredient of explosive mixtures for detonating rivets, P.<sup>9, 10</sup> \*

See Aluminum Flares, Ammonal, Thermite, F8.

## ALUMINUM FLARES

*Composition:* Mixtures of chlorates, perchlorates, or nitrates, with aluminum powder or flakes, and a binder, such as shellac, and with or without addition of sulfur.

*Properties:* Burn with an intensely brilliant light, white or colored, according to composition.

*Uses:* In aviation for signaling and for illuminating landing fields and military objectives.

See Potassium Chlorate, Potassium Perchlorate, Strontium Nitrate.

## AMATOL

*Composition:* Mixtures of trinitrotoluene (TNT) and ammonium nitrate in various proportions.

AMMONIUM NITRATE	TNT	RATE OF DETONATION	
80	20	5100 m/sec. (d	1.5)
50	50	7000 m/sec. (d	1.6)

*Properties:* The ammonium nitrate in Amatol acts as an oxidizer and provides more complete combustion of

\* The letter P with a numeral or numerals refers to patents quoted in the bibliography, section "Patents."



the oxidizable elements. Amatol explodes without smoke, whereas TNT on explosion produces a black smoke. If smoke is desired, special smoke boxes have to be included in the shell charge. Amatol is cheaper and produces more gas than straight TNT. The 50/50 mixture has approximately the same strength as TNT but gives much less smoke, which makes range-finding more difficult. Mixtures containing up to 50 per cent ammonium nitrate are cast directly in the shell; Amatol containing 80 per cent ammonium nitrate is pressed into the shell by a device known as an extruder.

*Uses:* Widely used as a bursting charge for high-explosive shells and bombs, particularly under conditions of actual or potential toluene shortage. Use of Amatol in place of straight TNT permits stretching the available toluene supplies.

See Phosphorus Red, Trinitrotoluene.

## AMERICAN

A brand of nongelatinous permissible explosives, manufactured by American Cyanamide and Chemical Corporation, New York, N. Y.

See Permissible Explosives.

## AMIDPULVER (AMID POWDER)

*Composition:* A powder containing:

	PER CENT
Potassium nitrate .	. 40
Ammonium nitrate	. 38
Charcoal . . .	. 22

An improved Amidpolver has the composition:

	PER CENT
Potassium nitrate .	. 14
Ammonium nitrate	. 37
Charcoal . . .	. 49

*Properties:* Gives a flashless and almost smokeless discharge when fired from a gun but has the disadvantage of being highly hygroscopic.

*Uses:* Was used by German Army as cannon powder in World War I.

## AMMONAL

*Composition:* Explosive mixtures containing aluminum, ammonium nitrate, and TNT.

Example of mixture used in World War I:

	PER CENT
TNT . . . . .	15
Ammonium nitrate . . . . .	65
Charcoal . . . . .	3
Aluminum powder . . . . .	17

*Properties:* Explosion of Ammonal makes a brilliant flash and develops great heat and correspondingly high pressure.

*Uses:* Was used in World War I as shell-filler, and for blasting and tunneling.<sup>1</sup>

## AMMONDYNAMITE

A French Ammonia Dynamite.

*Composition:*

	PER CENT
Ammonium nitrate . . . . .	45
Nitroglycerine . . . . .	40
Wood or cereal meal . . . . .	10
Sodium nitrate . . . . .	5

*Properties:* Loose, moist, greasy powder.

*Uses:* See Ammonia Dynamite.

## AMMONIA

*Composition:*  $\text{NH}_3$

*Properties:* Colorless gas, pungent odor. Vapor density 0.78.\* B. P.  $-33.4^\circ$ . Liquefies under pressure. Readily soluble in water (ammonia water).

\* Vapor densities are stated in comparison to vapor density of air = 1.

*Uses:* For producing smoke and fog.  
See Silicon Tetrachloride, Titanium Tetrachloride.

## AMMONIA DYNAMITE

*Composition:* Dynamite in which ammonium nitrate is substituted for a portion of the nitroglycerine. The remaining nitroglycerine serves as a sensitizer for the detonation of the ammonium nitrate. Example for a 40 per cent ammonia dynamite:

	PER CENT
Explosive oil . .	. 15
Ammonium nitrate	. 32
Sodium nitrate .	. 38
Sulfur . . . .	. 4
Vegetable meal .	. 9
Antacid. . . .	. 1
Moisture . . . .	. 1

“Ammonia Permissibles” have commonly contained:

	PER CENT
Nitroglycerine . .	10–15
Ammonium nitrate	60–80

and a relatively low percentage of absorbent material together with occasional small amounts of so-called safety ingredients, such as hydrated salts, sodium chloride, and sodium nitrate.<sup>23</sup>

Example of a low-density dynamite, P<sup>34</sup>.

	PER CENT
Nitroglycerine . .	. 15
Ammonium nitrate	. 58
Sodium nitrate .	. 9
Cornstalk pith. .	. 18

*Properties:* Of granular nature, not readily resisting the absorption of moisture. Not as quick and shattering as the corresponding grades of straight dynamite. Speed range from 9100–13,000 ft/sec. Strength range

from 15–60 per cent. A 30 per cent ammonia dynamite will release the same energy as a 30 per cent straight dynamite.

*Uses:* For work in soft rock, or in hard rock where a shattering effect is not desired; also in sand, clay, and earth excavation where the material is a little too hard for blasting powder. Has to a large extent displaced the straight nitroglycerine dynamite.

See Dynamite, Straight Dynamite, Permissible Explosives.

## AMMONIA GELATINE DYNAMITE

*Composition:* A gelatine dynamite containing ammonium nitrate.

Example of composition:

	PER CENT
Ammonium nitrate	. 45
Nitroglycerine . .	. 45
Gelatinized with	
Collodion cotton	. 2.5
Balance wood flour	

*Properties:* Slightly less water-resistant than the straight nitroglycerine grades but productive of smaller volumes of obnoxious fumes. Speed range confined, 14,500–17,500 ft/sec. Strength range from 30–90 per cent.

*Uses:* For underground quarrying and mining operations in hard rock, and for tunneling.

## AMMONITE

A group of safety explosives consisting of ammonium nitrate, often with some potassium nitrate, and nitro compounds of naphthalene or toluene. The oldest ammonites did not contain any nitroglycerine; they there-

fore had low sensitiveness and defective propagation. Later types had small amounts of nitroglycerine added, which provided not only higher sensitivity and better propagation, but it also changed the physical nature of the explosives, to the effect that they were easier to work and had less tendency to form dust.

*Composition:* Example:

	PER CENT
Ammonium nitrate, of which up to 10 per cent of the total explosive may be re- placed by potassium ni- trate . . . . .	77-87
Vegetable meal and/or solid hydrocarbon. . . . .	1-6
Nitro derivatives of toluene, naphthalene, or diphenyla- mine . . . . .	10-18
Nitroglycerine (also gelati- nized) . . . . .	3-4

*Uses:* Ammonites are the main types of explosives used in industrial practice in U. S. S. R. They are mechanical mixtures of ammonium nitrate with nitro derivatives such as dinitronaphthalene or with combustible materials such as coal or sawdust. They have low sensitivity to shock or friction. Hygroscopicity and deterioration are their main disadvantages.<sup>2</sup>

## AMMONIUM CHLORIDE (SAL AMMONIAC)

*Composition:*  $\text{NH}_4\text{Cl}$

*Properties:* Colorless crystals or white powder, somewhat hygroscopic. Sp. gr. 1.53 at 17°. Sublimes without melting.

*Uses:* In smoke mixtures and in some permissible gelatine dynamites. See HC Mixture.

## AMMONIUM NITRATE

*Composition:*  $\text{NH}_4\text{NO}_3$

*Properties:* White crystals. Sp. gr. 1.725. M. P. 155–166°. Decomposes at 210°. Very hygroscopic. Explosives containing ammonium nitrate may be protected from moisture by suitable coating, such as oily nitro compounds, or by selection of waterproof material for cartridges (paraffin). It is a high explosive, very insensitive to impact and difficult to detonate, requiring a combination of an initiator and a high explosive (reinforced detonators).

*Uses:* In combination with TNT or other nitro bodies it is one of the major high explosives in war usage for filling shells. It is widely used as a component of Ammonia Permissibles and of Ammonia Dynamites and is also a component of many pyrotechnical mixtures. It is used as a granular blasting explosive in combination with smokeless powder,  $\text{P}^{23}$ , and in low-density dynamites in combination with balsa meal, cork, corn-stalk pith,  $\text{P}^{24,33,34,40}$ .

See Amatol, Ammonal, Ammonia Dynamite, Ammonia Gelatine, Dinitrobenzene, Dinitronaphthalene, Trinitrocresol, Trinitroxylene, Guanidine Nitrate,  $\text{P}^{15}$ .

## AMMONIUM NITRATE EXPLOSIVES

Types of explosives containing large amounts of ammonium nitrate. The oldest of these explosives (see Roburit, Favier Explosives) contain no nitroglycerine; they consist of ammonium nitrate, often with some potassium nitrate, and aromatic di- and trinitro products. Their disadvantages are low sensitiveness and defective propagation. Later improved ammonium nitrate explosives contain small amounts of nitroglycerine. The nitroglycerine permeates the pulverent

explosive and "moistens" it somewhat, ensuring detonation and propagation. Velocity of ammonium nitrate explosives can be varied by control of the particle size of the ammonium nitrate, lower velocities being obtained by using coarser particles, P<sup>25</sup>. Ammonium nitrate permissibles are the most popular type, constituting more than 70 per cent of the permissibles used in this country.

*Uses:* As safety and permissible explosives.  
See Astralit, Ammonit, Monobel.

## AMMONIUM OXALATE

*Composition:*  $(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$

*Properties:* Colorless crystals. Sp. gr. 1.5.

*Uses:* In permissible dynamites (See). As dehydrating agent in blasting explosives, P<sup>14</sup>.

## AMMONIUM PERCHLORATE

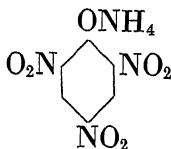
*Composition:*  $\text{NH}_4\text{ClO}_4$

*Properties:* Colorless crystals. Sp. gr. 1.95. M. P. decomposes. Soluble in water. Less sensitive than chlorates. May explode in a fire.

*Uses:* In detonating and pyrotechnic compositions.<sup>17</sup>  
See HC Mixture.

## AMMONIUM PICRATE (EXPLOSIVE "D") (DUNNITE)

*Composition:* Ammonium salt of 2,4,6-trinitrophenol,  $\text{C}_6\text{H}_2(\text{ONH}_4)(\text{NO}_2)_3$



*Properties:* Yellow to red crystals or granules. Does not melt on heating but explodes when heated to 300°. It must be loaded in projectiles by pressing or tamping. Ammonium picrate absorbs moisture and in wet condition reacts slowly with metals, particularly copper and lead, to form picrates which are sensitive and dangerous. Its explosive strength is inferior to that of TNT, but it is very valuable because of its extreme resistance to impact, shock, and friction. It is not detonated by fulminate. Commonly used with a booster of picric acid or Tetryl. Rate of detonation 6500 m/sec. ( $d = 1.45$ ).

*Uses:* Standard bursting charge for armor-piercing shells.

## AMMONPULVER

*Composition:* A mixture of 80–90 per cent ammonium nitrate and 10–20 per cent charcoal, with or without addition of potassium nitrate.

*Properties:* Cheap, flashless, smokeless, but very hygroscopic. Comparable in ballistic properties with smokeless powder.

*Uses:* Was used as propellant powder in World War I in Germany and Austria.

## ANILITE

*Composition:* Mixture of liquefied nitrogen dioxide with carbon disulfide or gasoline.

*Properties:* Powerful, readily exploded by shock.

*Uses:* Used in World War I in bombs having two compartments and a special device for mixing the previously separated components after bomb was released from the airplane.<sup>7</sup>



**ANTHRACENE**

*Composition:* High-boiling coal-tar hydrocarbon,  $C_{14}H_{10}$



*Properties:* Colorless solid with blue fluorescence. Sp. gr. 1.147. M. P. 218°. B. P. 342°.

*Uses:* Was used in trench warfare for producing gray smokes.

See Zinc Dust

**ANTHRACITE**

A brand of nongelatinous permissible explosives manufactured by Independent Explosive Company of Pennsylvania, Pittsburgh, Pa.

See Permissible Explosives.

**ANTIMONY SULFIDE**

*Composition:*  $Sb_2S_3$

*Properties:* Lustrous crystalline masses or grayish-black powder in mineral form, or orange-red crystals (precipitated). Sp. gr. 4.64. M. P. 550°.

*Uses:* In combination with mercury fulminate and potassium chlorate as fuel component in percussion primer compositions. This mixture provides a more prolonged blow and a bigger flame than can be given by mercury fulminate alone. In incendiary projectiles, P<sup>5</sup>. As rust-inhibitor in smokeless powder, P<sup>17</sup>.

**APACHE COAL POWDER**

A brand of nongelatinous permissible explosives manufactured by Apache Powder Co., Benson, Ariz.

See Permissible Explosives.

## APCOAL

A brand of nongelatinous permissible explosives manufactured by Atlas Powder Co., Wilmington, Del.  
See Permissible Explosives.

## AQUINITE

French name for Chlorpicrin (See).

## ARSENIC TRICHLORIDE

*Composition:*  $\text{AsCl}_3$

*Properties:* Yellowish, oily liquid. Sp. gr. 2.20 at  $0^\circ$ . M. P.  $18^\circ$ . B. P.  $130^\circ$ . Decomposed by much water into  $\text{As}_2\text{O}_3$  and  $\text{HCl}$ .

*Uses:* For stabilizing chemical warfare agents containing the cyanogen group. As smoke-producing agent. See Cyanogen Chloride, Vincennite.

## ARSENIOUS OXIDE (ARSENIC TRIOXIDE)

*Composition:*  $\text{As}_2\text{O}_3$

*Properties:* White glassy mass or powder. Sp. gr. 3.865 at  $25^\circ$ . Sublimes.

*Uses:* In smoke-producing compositions. See Phosphorus Red.

## ASTRALIT

One of the first improved ammonium nitrate explosives, containing a small amount of nitroglycerine.

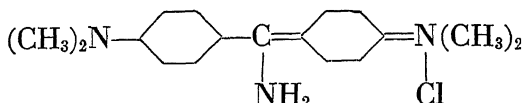
*Composition:* Example:

	PER CENT
Ammonium nitrate . . . . .	80
Trinitrotoluene . . . . .	12
Vegetable meals . . . . .	4
Nitroglycerine . . . . .	3
Charcoal . . . . .	1

For properties and uses, see Ammonium Nitrate Explosives.

## AURAMINE

*Composition:*



*Properties:* Bright-yellow dye.

*Uses:* To produce yellow-colored smoke for military signaling from shells, rockets, or pots. In mixture with indigo for producing green-colored smoke.

## AUSTIN RED-D-GEL

A brand of gelatinous permissible explosives manufactured by Austin Powder Co., Cleveland, O.

See Permissible Explosives.

## AUSTIN RED DIAMOND

A brand of nongelatinous permissible explosives manufactured by Austin Powder Co., Cleveland, O.

See Permissible Explosives.

## BA

British and Chemical Warfare symbol for Bromacetone (See).

## BAGASSE PITH

A low-density combustible material used as absorbent for low-density permissibles,<sup>23</sup> P<sup>24</sup>.

See Permissible Explosives.

## BALLISTITE

One of the first military smokeless powders, invented by Nobel, composed of about 59 per cent nitrocellu-

lose (mostly collodion cotton with some guncotton) and 41 per cent nitroglycerine.  
See Double-Base Powders.

## BALL POWDER

*Composition:* A nitrocellulose smokeless powder produced in spherical form by a simplified process in which stabilization, gelatinization, and solvent recovery are carried out in one operation, P<sup>1,12,27</sup>.

*Uses:* As propellant for ammunition up to 37-mm. caliber.

## BALSA MEAL

A low-density combustible material used as absorbent for low-density permissibles,<sup>23</sup> P<sup>24</sup>.  
See Permissible Explosives.

## BARIUM NITRATE

*Composition:* Ba(NO<sub>3</sub>)<sub>2</sub>

*Properties:* Colorless crystals or white powder. Sp. gr. 3.244 at 23°. M. P. 575°. Gives green light on burning. Grade A (99.8 per cent purity) for use in priming compositions. Grade B (99.0 per cent purity) for use in pyrotechnic compositions.

*Uses:* In place of potassium chlorate in percussion primer compositions, with the object of producing noncorrosive primers, P<sup>4</sup>. Also in pyrotechnic compositions, in blasting explosives, and in some compound propellants. See Double-Base Powders, E. C. Powder, Poudre B. N., Tonite, Strontium Nitrate, F8.

## BARIUM PEROXIDE

*Composition:* BaO<sub>2</sub>

*Properties:* Grayish-white powder. Sp. gr. 4.96.

*Uses:* Primer in combination with aluminum for thermit bombs. In tracer ammunition, P<sup>3</sup>.

## BELGIAN PERMITE

*Composition:*

	PER CENT
Ammonium nitrate . . . . .	78
TNT . . . . .	8
Calcium silicide . . . . .	14

*Properties:* Dark-gray powder readily set off by service detonators.

*Uses:* Used in World War I by Belgians.<sup>1</sup>

## BELLITE

*Composition:* A series of high ammonium nitrate explosives used for coal mining. Originally they contained nitrobenzene. This was later replaced by dinitrobenzene, which is preferable because it is solid and more effective.

	PER CENT
Ammonium nitrate	82-93
Dinitrobenzene .	18-7

## BICKFORD FUSE

*Composition:* A safety fuse, having a core of black powder enclosed within a tube of woven threads, surrounded by various layers of textile, waterproof material, sheathing, etc.

*Properties:* When ignited on one end it burns comparatively slowly (about 1 ft/min.). When the fire reaches the other end, a spit of flame shoots out.

*Uses:* As miners' fuse, for igniting black powder or for firing a blasting cap.

See Cordeau Bickford, Primacord-Bickford.

**BIG COAL D**

A brand of nongelatinous permissible explosives manufactured by Liberty Powder Co., Pittsburgh, Pa.  
See Permissible Explosives.

**BIG RED**

A brand of nongelatinous permissible explosives manufactured by Equitable Powder Manufacturing Co., and Egyptian Powder Co., East Alton, Ill.  
See Permissible Explosives.

**BITUMINITE**

A brand of nongelatinous permissible explosives manufactured by Hercules Powder Co., Wilmington, Del.  
See Permissible Explosives.

**BLACK DIAMOND**

A brand of nongelatinous permissible explosives manufactured by Illinois Powder Manufacturing Co., St. Louis, Mo.  
See Permissible Explosives.

**BLACK DIAMOND NU-GEL**

A brand of gelatinous permissible explosives manufactured by Illinois Powder Manufacturing Co., St. Louis, Mo.  
See Permissible Explosives.

**BLACK POWDER (GUNPOWDER)**

The original standard military propellant. Now obsolete for this purpose.

*Composition:*

	PER CENT
Potassium nitrate . . . . .	70-75
Charcoal . . . . .	14-16
Sulfur . . . . .	10-14

*Properties:* Black, granular powder. Burns with explosive rapidity when ignited under confinement. It is a deflagrating powder, in distinction from high explosives which detonate.

*Uses:* See Black Powder (With Potassium Nitrate) and Black Powder (With Sodium Nitrate).

## BLACK POWDER (WITH POTASSIUM NITRATE) (U. S. ARMY BLACK POWDER)

*Composition:*

	PER CENT
Potassium nitrate . . . . .	74.0
Charcoal . . . . .	15.6
Sulfur . . . . .	10.4

*Properties:* Readily ignited by flame. Evolves about 700 calories of heat and 300 cc. of gas per gram. Various grades, specified by fineness. The fuze powder for loading time-train rings is the finest grade (passing a 140-mesh screen).

*Uses:* It was the standard propellant powder prior to the introduction of smokeless powder. It is now used as bursting charge in 37 mm. Low-Explosive shells. As expelling charge for shrapnel shell. In ignition charges, primers, and igniter bags; in time-train rings, combination fuzes, and safety fuses. It may be noted here that it is now customary to spell safety fuse with *s*, whereas for mechanical fuzes the spelling is with *z*. A safety fuse is the medium used to carry fire to a blasting cap. The fuse consists of a core of fine black powder enclosed in wrappings of yarn or tape and is waterproofed to a degree which is variable according to brand and quality. A fuze is a mechanism for igniting or detonating the bursting charge of a projectile. This function is being performed either upon impact or at a certain

time during flight. A combination fuze combines both percussion and time elements.

See Blasting Powder A, Cocoa Powder, Fuse Powder.

## BLACK POWDER (WITH SODIUM NITRATE) (U. S. ARMY BLACK POWDER)

*Composition:*

	PER CENT
Sodium nitrate . . . . .	71.0
Sulfur . . . . .	12.5
Charcoal . . . . .	16.5

*Properties:* Slightly less water-resistant, weaker and slower than black powder with potassium nitrate, but less expensive.

*Uses:* Class A (in pellet form) for saluting charges, and Class B (in powder form) for practice bombs.

See Blasting Powder B.

## BLASTINE

*Composition:*

	PER CENT
Ammonium perchlorate . . . . .	60
Sodium nitrate . . . . .	22
Paraffin wax . . . . .	7
TNT . . . . .	11

Wax provides combustible material for excess oxygen in chlorate and nitrate.

*Uses:* Used in World War I for mining.<sup>1</sup>

## BLASTING GELATINE (NITROGLYCERINE GELATINE) (TORPEDO EXPLOSIVE NO. 1)

The most powerful explosive used industrially, introduced by Alfred Nobel.

*Composition:* A colloid of nitroglycerine and soluble nitrocellulose (collodion cotton), containing about 7-8 per cent of the latter.



*Properties:* A translucent material with an elastic texture like para rubber. Strongest, quickest, and most waterproof explosive. It has an extremely high velocity and is rated at 100 per cent strength. It is sometimes sold under the name, "Torpedo Explosive No. 1." Rate of detonation 7800 m/sec. ( $d = 1.63$ ).

*Uses:* For special cases of tunnel-driving, shaft-sinking, deep-well shooting, and submarine work.

## BLASTING OIL

Industrial term for nitroglycerine (See). Now obsolete.

## BLASTING POWDER A

*Composition:* A grained black powder, containing potassium nitrate, prepared in grains closely resembling fine lumps of high-grade coal.

*Properties:* Slightly more moisture-resistant, stronger, and quicker than Blasting Powder B, which contains nitrate of soda instead of the saltpeter.

*Uses:* In certain cases of difficult blasting, as in quarrying fine-dimension stone.

See Black Powder (With Potassium Nitrate).

## BLASTING POWDER B

*Composition:* A grained black powder, containing sodium nitrate, and glazed with graphite for protection from moisture.

*Properties:* Produced in standard granulations from fine to coarse, the burning-speed increasing with the fineness. Much cheaper than Blasting Powder A, therefore more generally used for blasting.

See Blasting Powder A.

*Uses:* In stripping, where material is not too hard, in coal mines that are nongaseous, and in general excavating in light ground where a slow, heaving action is desired and where the work is dry.

See Black Powder (With Sodium Nitrate).

See Pellet Powder.

## BLEACHING POWDER (CHLORINATED LIME)

*Composition:* Variable, approximately  $\text{CaCl}_2\text{Ca}(\text{OCl})_2$ .

*Properties:* White powder with strong chlorine odor. Slightly soluble in water, with decomposition. Sp. gr. 2.08.

*Uses:* For decontamination of surfaces exposed to mustard gas or Lewisite.

## BLUE CROSS (BLAU KREUZ)

German designation for irritating chemical agents (sneeze gases, sternutators).

See Diphenylchlorarsine, Phenylchlorarsine.

## BOOSTERS

A class of relatively sensitive high explosives, the chief representative of which is Tetryl.

*Properties:* More sensitive and powerful than those high explosives which are used as main bursting charge, but less sensitive than primary explosives.

*Uses:* In the explosive train of H. E. shell between the primary explosive and the main bursting charge to insure complete detonation of the bursting charge and to permit the use of a smaller amount of the dangerous primary explosive.

See Tetryl, Hexanitrodiphenylamine, Tetranitroaniline.

## BRIMSTONE

Commercial term for Sulfur (See).

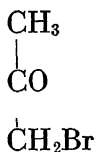
## BROMACETONE

American and British: BA.

French: Martonite.

German: B Stoff.

*Composition:*  $\text{BrCH}_2\text{COCH}_3$



*Properties:* Colorless liquid. B. P.  $136^\circ$ . Sp. gr. 1.64 at  $20^\circ$ . Vapor density 4.75. M. P.  $-54^\circ$ . Not decomposed by water. Polymerizes on long standing and under the influence of heat and light.

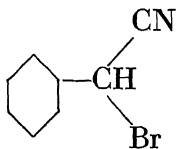
*Uses:* Powerful lacrimator; was used in artillery shells and other weapons throughout World War I. Was beginning to be replaced by the more effective bromobenzylcyanide toward the close of the war. It was also used for testing of gas masks in gas chambers.

## BROMBENZYL CYANIDE

American: CA.

French: Camite.

*Composition:*  $\text{C}_6\text{H}_5\text{CHBrCN}$



*Properties:* Oily Liquid, yellowish crystals when pure, soured fruity odor. Decomposed by heat and during distillation. Corrosive to metals. M. P. 29°. B. P. 232°. Vapor density 6.8.

*Uses:* Most powerful lacrimator used in World War I. First used by French in July, 1918. Tactical possibilities limited by its technical properties.

*First aid:* Wash eyes with boric acid.

*Field neutralization:* Alcoholic sodium hydroxide spray.

## B STOFF

German name for Bromacetone (See).

## BURSTING-CHARGE EXPLOSIVES

Are characterized by being relatively insensitive and by having high brisance or shattering power.

See Trinitrotoluene, Picric Acid, Ammonium Picrate, High Explosives.

## BURTON A

A brand of nongelatinous permissible explosives manufactured by American Cyanamide and Chemical Corporation, New York, N. Y.

See Permissible Explosives.

## BUTYL RICINOLEATE

*Composition:*  $C_{18}H_{33}O_3C_4H_9$

*Properties:* Yellow, oleaginous liquid. Sp. gr. 0.916 at 20°. Flash point 220°.

*Uses:* As deterrent coating in smokeless powder, P<sup>16</sup>.

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CA

Chemical Warfare symbol for Brombenzylcyanide (See).

**CALCIUM CARBONATE (PRECIPITATED CHALK)**

*Composition:*  $\text{CaCO}_3$

*Properties:* White powder. Sp. gr. 2.71–2.95.

*Uses:* As stabilizing and neutralizing agent in explosive mixtures or in compositions which tend to develop acidity.

See HC Mixture, Dynamite.

**CALCIUM NITRATE MONOHYDRATE**

*Composition:*  $\text{Ca}(\text{NO}_3)_2 \cdot \text{H}_2\text{O}$

*Properties:* White deliquescent granules. Melts at about 560°. Soluble in water and alcohol.

*Uses:* In pyrotechnics and in blasting explosives, P<sup>43</sup>.

**CALCIUM RESINATE**

*Composition:* Calcium salt of the acid constituents of resin.

*Properties:* Sp. gr. 2.5.

*Uses:* As binder in manufacture of tracer powders.

**CALCIUM SILICIDE**

*Composition:*  $\text{CaSi}_2$

*Properties:* Sp. gr. 2.5.

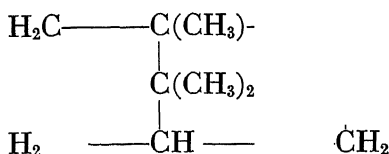
*Uses:* In detonating and primer compositions.

**CAMITE**

French name for Brombenzylcyanide (See).

**CAMPHOR**

*Composition:*  $C_{10}H_{16}O$



*Properties:* Colorless crystals with characteristic odor. Sp. gr. 0.999 at 9°. M. P. 175°. B. P. 204° (sublimes).

*Uses:* Addition of 3–5 per cent camphor to blasting gelatine reduces the sensitiveness to detonation and makes it more resistant to mechanical influences. It is used for the same purpose in double-base powders containing nitroglycerine, where it also acts as a stabilizer.

**CANNON POWDER**

Large-size grains of smokeless powder used in separate-loading artillery ammunition.

See Pyrocotton.

**CARBAZOLE (DIPHENYLENE IMIDE)**

*Composition:*  $(C_6H_4)_2NH$

*Properties:* White to reddish-white crystals. Soluble in alcohol and ether. M. P. 244°. B. P. 352°.

*Uses:* As stabilizer in smokeless powder.<sup>20</sup>

**CARBOLIC ACID**

Synonym for Phenol (See).

**CARBON BLACK**

*Composition:* Fluffy, extremely finely divided form of carbon.

*Uses:* See Liquid-Oxygen Explosives.

**CARBON DIOXIDE (CARBONIC ACID)**

*Composition:*  $\text{CO}_2$

*Properties:* Colorless, odorless gas. Also comes in liquid form. Sp. gr. Gas 1.53  
Liquid 1.06  
Solid 1.56

M. P.  $-65^\circ$ . B. P.  $-80^\circ$ .

*Uses:* For providing pressure in cylinders containing silicon tetrachloride (See).

**CARBONITE**

A mixture of nitroglycerine, oak bark, and sodium or potassium nitrate. Was used in Germany and England as a permissible explosive.

**CARBONYL CHLORIDE**

Synonym for Phosgene (See).

**CASTOR OIL**

*Composition:* A vegetable oil consisting chiefly of glycerides of unsaturated fatty acids.

*Properties:* Pale-yellow oily liquid with characteristic odor. Sp. gr. 0.95 at  $25^\circ$ . Solidifies  $-10^\circ$  to  $-18^\circ$ .

*Uses:* For coating magnesium particles which are to be used for pyrotechnic purposes, as a protection from moisture, P<sup>2</sup>.

See also Chlorate Explosives, Cheddite.

**CAUSTIC SODA (SODIUM HYDROXIDE)**

*Composition:*  $\text{NaOH}$

*Properties:* White lumps, pellets, or flakes. Sp. gr. 2.13. Hygroscopic and very caustic to tissue. Strong base, capable of neutralizing any acidic substance.

*Uses:* See Phenate Hexamine and Soda Lime.

**CDA**

Chemical Warfare Symbol for Diphenylcyanarsine (See).

**CELLULOSE NITRATE**

Correct chemical term for what is commonly but erroneously called nitrocellulose. The product formed by action of a mixture of nitric and sulfuric acids on cellulose is an ester and not a nitro compound, having the empirical formula  $[C_6H_7O_2(ONO_2)_3]_x$ .

Since the exact molecular weight of cellulose is unknown and since degradation of the cellulose molecule takes place during the reaction, it is not possible to assign absolute formulas to cellulose derivatives. It has been customary to express the degree of esterification ("nitration") in terms of a unit of six, twelve, or twenty-four carbon units. The custom today is to differentiate products by nitrogen content rather than by formulas. The products of various degrees of nitration are grouped from the point of view of their properties and commercial utilization.

For composition, properties, uses of representatives of the various groups, see Nitrocellulose, Dodekanitrocellulose, Hexanitrocellulose, Trinitrocellulose, Gun-cotton, Pyrocotton, Collodion Cotton, Blasting Gelatine.

**CEMENT**

*Composition:* A binding material consisting essentially of calcium aluminum silicate.

*Properties:* Fine, gray powder. Mixed with a small quantity of water, it sets to a hard, tenacious mass.

*Uses:* In gas masks. See Soda Lime.

**CENTRALITE I AND II**

Commercial names for Diphenyldiethylurea and Diphenyldimethylurea (See).



Chemical Warfare symbol for Phosgene (See).

## CHARCOAL (WOOD CHARCOAL) (ACTIVATED CHARCOAL)

*Composition:* Black powder or lumps consisting chiefly of carbon and containing 2-5 per cent ash.

*Properties:* Ease of ignition varies with temperature of carbonization.

*Uses:* Chief combustible ingredient of black powder. Component of gas-mask material. For the latter purpose an activated product is being used. See Activated Charcoal, Red Charcoal.

## CHEDDITE

French chlorate explosives used for industrial and military blasting operations.

*Composition:* Chlorates or perchlorates in combination with aromatic nitro compounds such as nitronaphthalene.

See Chlorate Explosives.

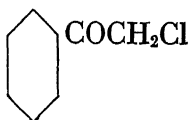
## CHILE SALTPETER

Common name for Sodium Nitrate (See).

## CHLORACETOPHENONE (CHLOROACETOPHENONE) (PHENACYL CHLORIDE) (PHENYLCHLOROMETHYLKETONE)

Chemical Warfare Symbol: CN

*Composition:*  $C_6H_5COCH_2Cl$



*Properties:* Colorless, crystalline mass. Odor resembling apple blossom. M. P. 58–59°. B. P. 245°. Resistant to heat and moisture and does not corrode metals. Soluble in ordinary organic solvents. Very powerful lacrimator, irritating effect equaling that of brombenzylcyanide.

*Uses:* Was developed by Chemical Warfare Service late in 1918 but was not used during World War I. Can be used in explosive shells or bombs or in burning compositions which distill the irritant gas into the air without explosion.

*Field neutralization:* Strong, hot solution of sodium carbonate.

## CHLORACETOPHENONE SOLUTIONS

Chemical Warfare Symbol: CNB

*Composition:* Solution of chloracetophenone in carbon tetrachloride and benzol.

Chemical Warfare Symbol: CNS

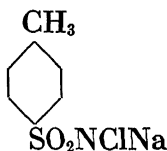
*Composition:* Solution of mixture of chlorpicrin and chloracetophenone in chloroform.

*Properties:* Harassing agents.

*Uses:* Suitable for use in small airplane bombs and sprays, artillery and chemical mortar shells, hand grenades.

## CHLORAMINE-T (SODIUM *p*-TOLUENESULFONCHLORAMIDE)

*Composition:*  $\text{CH}_3\text{C}_6\text{H}_4\text{SO}_2\text{NCINa}$



*Properties:* White crystals or powder, slight chlorine odor. Soluble in water.

*Uses:* As decontaminating agent for mustard gas.

## CHLORATE EXPLOSIVES

Manufacture of these explosives received great impetus in Germany and France during World War I, probably on account of the lack of nitrogen compounds.

*Composition:* The chief constituent, 60–80 per cent, is a chlorate or perchlorate of ammonium, sodium, or potassium. The other ingredients are combustible products such as charcoal, sulfur, aluminum powder, or mixtures of vegetable meals; nitro derivatives of benzene, toluene, naphthalene, phenol; and as desensitizers solid hydrocarbons (paraffin) and castor oil may be added. The addition of the nitro compounds serves to improve the propagation.

Similar mixtures were later used in Germany but with further addition of small amounts of nitroglycerine or collodion cotton, which served to raise the brisance. See Coronite, Percoronite.

*Properties:* More sensitive than the modern Permissible Explosives. The Perchlorate Explosives are less sensitive to detonation and therefore safer than the Chlorate Explosives. The plastic mixtures containing nitroglycerine are somewhat less sensitive to shock and friction, in spite of the nitroglycerine present, than the drier explosives with no nitroglycerine.

*Uses:* See Cheddite, Coronite, Percoronite, and P<sup>11</sup>.

## CHLORINATED LIME

See Bleaching Powder.

## CHLORINE

*Symbol:* Cl<sub>2</sub>

Chemical Warfare Symbol: Cl

*Properties:* Greenish-yellow gas or liquid.

Gas: Vapor density 2.49 at 0°. Highly pungent, suffocating odor.

Liquid: Sp. gr. 1.468 at 0°. B. P. -34.6°. Critical temperature 146°.

*Uses:* Was the first toxic gas used in World War I. German chlorine attack near Ypres, April 2, 1915. Later replaced by more effective gases. May be used in cylinders and shells in mixture with phosgene or chlorpicrin.

*Field neutralization:* Alkaline solutions.

### CHLORPICRIN (CHLOROPICRIN) (TRICHLORONITROMETHANE) (NITROCHLOROFORM)

Chemical Warfare Symbol: PS

British: Vomiting Gas

German: Klop

French: Aquinite

*Composition:*  $\text{CCl}_3\text{NO}_2$

*Properties:* Colorless liquid; sweetish, highly pungent odor. Sp. gr. 1.66 at 20°. M. P. 69°. Vapor density 5.6. B. P. 113°. Lung irritant; has also strong lacrimatory properties; is absorbed by charcoal.

*Uses:* First used in World War I by Russians in 1916, later generally adopted.

*Protection:* Gas mask.

*Field neutralization:* Alcoholic solution of sodium sulfite.

### CHLORSULFONIC ACID—SULFUR TRIOXIDE SOLUTION

Chemical Warfare Symbol: FS

*Composition:* A mixture containing about 55 per cent by weight of sulfur trioxide ( $\text{SO}_3$ ) and 45 per cent of chlorsulfonic acid ( $\text{HClSO}_3$ ).

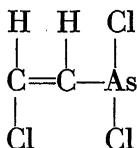
*Properties:* A liquid reacting with moisture of air to form dispersions of fine droplets, producing a white smoke, which causes prickling of skin, flow of tears.

*Uses:* Smoke-producing material. Was used by the German Navy in the battle of Jutland.

**CHLORVINYLDICHLORARSINE**  
**(LEWISITE) (BETA-CHLORVINYLDICHLORARSINE)**  
**(CHLORVINYLDICHLOROARSINE)**

Chemical Warfare Symbol: M-1

*Composition:* Chlorvinyldichlorarsine containing some dichlordivinylchlorarsine and trichlortrivinyarsine.



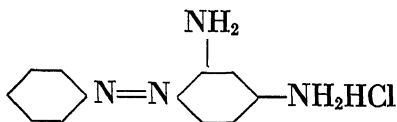
*Properties:* Oily liquid having a geranium odor. Sp. gr. 1.88. B. P. 190°. A persistent, violent vesicant, highly toxic (arsenical poison). Can be used in liquid or vapor form, in other words, in shells, bombs, or as a spray. Decomposed by hydrolysis. Alcoholic sodium hydroxide spray used as means of destroying the product in the field, after first washing down with water.

*Uses:* Manufacture was started by Chemical Warfare Service, October, 1917, at Edgewood Arsenal. Was not used during World War I.

*Protection:* Gas mask and full protective clothing.

**CHRYSOIDINE**

*Composition:* Aniline azo-*m*-phenylenediamine chloride.



*Properties:* Crystal powder or large black crystals.

*Uses:* To produce yellow-colored smoke for signaling from shells, rockets, grenades, or pots.

## CLARK I

See Diphenylchlorarsine.

## CN, CNB, CND, CNS

See Chloracetophenone.

## COALITE

A brand of nongelatinous permissible explosives manufactured by the Atlas Powder Co., Wilmington, Del.

See Permissible Explosives.

## COCOA POWDER

*Composition:* Similar to black powder except for the use of a brown in place of a black charcoal. Approximate composition:

	PER CENT
Saltpeter . . . . .	78
Brown charcoal . . . . .	19
(incompletely carbonized charcoal)	
Sulfur . . . . .	3

*Properties:* A cocoa-colored powder grained into single perforated hexagonal or octagonal prisms. It represented the most successful form of black powder for use in long-range rifled guns.

*Uses:* Was used as propellant powder up to the time of the Spanish War, 1898.

## COLLIER

A brand of nongelatinous permissible explosives manufactured by Hercules Powder Co., Wilmington, Del. See Permissible Explosives.

**COLLONGITE**

French term for Phosgene (See).

**COLLODION COTTON**

*Composition:* Cellulose nitrate mixture containing 11.2–12.2 per cent nitrogen. The product used for dynamite as a rule has a nitrogen content of 12.1–12.2 per cent.

*Properties:* White, pulped fibers, soluble in ether-alcohol and in nitroglycerine.

*Uses:* As gelatinizing agent for nitroglycerine in manufacture of Blasting Gelatine and Gelatine Dynamite. See Nitrocellulose, Oktonitrocellulose, Tetranitrocellulose, Enneanitrocellulose, Dekanitrocellulose.

**COLOPHONY**

See Rosin.

**COLUMBIA**

A brand of nongelatinous permissible explosives manufactured by Columbia Powder Co., Tacoma, Wash. See Permissible Explosives.

**COLUMBIA-GEL**

A brand of gelatinous permissible explosives manufactured by Columbia Powder Co., Tacoma, Wash. See Permissible Explosives.

**COPPER ACETYLIDE (CUPROUS ACETYLIDE) (CUPROUS CARBIDE)**

*Composition:*  $C_2Cu_2$



*Properties:* One of the very few commercial explosives containing neither nitrogen nor oxygen and producing no gas on decomposition. Explosion is due only to production of large amount of heat. Red-brown solid, detonates by percussion or when heated over 100°.

*Uses:* In ignition composition for commercial electric detonators.

## COPPER FULMINATE

*Composition:*  $\text{Cu}(\text{ONC})_2$

*Uses:* As detonator in gassy coal mines.

## CORDEAU-BICKFORD

*Composition:* A detonating tube (cordeau) made of lead, containing TNT as core, manufactured by the Ensign-Bickford Company at Simsbury, Conn.

*Properties:* Detonates with a velocity of about 5200 m/sec.

*Uses:* For firing blasting charges. As a standard for determining rate of detonation of other high explosives by the Dautriche method.

See Primacord-Bickford, Bickford Fuse.

## CORDITE

*Composition:* Combination of nitrocellulose and nitroglycerine containing 30–40 per cent of the latter and rendered more stable by addition of about 5 per cent mineral jelly (Vaseline).

*Properties:* Soluble in acetone, which is used for colloidizing the above mixture. Manufactured in form of cords.

*Uses:* Important military propellant (British Service Powder).

See Smokeless Powder, Double-Base Powders.



**CORDITE MD***Composition:*

	PER CENT
Nitroglycerine . . . . .	30
Guncotton . . . . .	65
Mineral jelly . . . . .	5

*Properties:* See Double-Base Powders.*Uses:* British rifle powder.**CORNSTALK PITH**

A low-density combustible material used as absorbent for low-density permissibles,<sup>23</sup> P<sup>24,34</sup>.

See Permissible Explosives.

**CORONITE**

A type of German blasting explosive based on chlorates.

*Composition:* Example:

	PER CENT
Sodium chlorate . . . . .	72
Vegetable meal . . . . .	1
Tri- and dinitrotoluene . . . . .	20
Paraffin . . . . .	4
Nitroglycerine . . . . .	3

*Uses:* In stone quarries and mines. Has been replaced by Percoronite (See).

For other properties and uses see Chlorate Explosives.

**CRESYLITE (CRESSYLITE)**

*Composition:* Mixtures of picric acid and trinitrocresol, for instance, 60/40.

*Properties:* Yellow solid. Sp. gr. 1.77. Can be loaded in molten condition.

*Uses:* As bursting charge, particularly in France. See Trinitrocresol.

**CRUDE OIL**

Chemical Warfare Symbol: CO

*Composition:* Mixture of petroleum hydrocarbons.

*Properties:* Viscous, highly colored oils. Sp. gr. 0.8. B. P. about 200°. Produces colloidal carbon by partial combustion.

*Uses:* For incendiary purposes in bombs and shells and for dark smoke screens by spraying it with an insufficient amount of air below the stacks of destroyers.

**C STOFF**

German term for Methylchlorsulfonate (See).

**CUPROUS ACETYLIDE**

See Copper Acetylide.

**CYANOGEN BROMIDE**

*Composition:* CNBr

*Properties:* White crystalline solid. Sp. gr. 2.02. M. P. 52°. B. P. 61.5°. Vapor density 3.6. It polymerizes on storage into a physiologically inert substance and decomposes on contact with metals. A systemic poison, but rather unsuitable for use as a chemical warfare agent on account of its instability.

*Uses:* Used during World War I by the Austrians in combination with other chemicals in CE shells.

**CYANOGEN CHLORIDE (VITRITE)**

*Composition:* CNCl

*Properties:* Colorless liquid. Sp. gr. 1.22. B. P. 14.0°. Vapor density 2.0. Volatility 3300 mg/liter at 20°. Polymerizes on storage, forming a less effective product. In mixture with arsenic trichloride it is far more stable. Systemic poison and very irritating.

*Uses:* With addition of arsenic trichloride as stabilizer in the French Vitrite shells.

## CYCLONITE

Common term for Trimethylenetrinitramine (See).

## CYCLOTRIMETHYLENETRINITRAMINE

Chemical synonym for Trimethylenetrinitramine (See).

## DA

Chemical Warfare symbol for Diphenylchlorarsine (See).

## DAISITE

A thermit composition containing sulfur as a binder. See Thermit.

## DD 60/40

*Composition:* A French explosive with the following composition:

	PER CENT
Picric acid . . .	. 60
Dinitrophenol .	. 40

*Properties:* Smaller-size crystals and lower melting point than straight picric acid, therefore more suitable for shell-loading.

*Uses:* As bursting charge for shells. See Dinitrophenol.

## DDNP

Symbol for Diazodinitrophenol (See).

## DECANITROCELLULOSE

*Composition:*  $C_{24}H_{30}O_{10}(NO_3)_{10}$ . Based on cellulose unit,  $C_{24}H_{40}O_{20}$ . Represents a degree of "nitration" of cellulose about equivalent to that of pyrocotton.

*Properties:* White, matted mass. 12.76 per cent nitrogen.

*Uses:* Chief constituent of smokeless powders.  
See Pyrocotton, Nitrocellulose, Smokeless Powder.

## DETERRENT

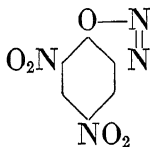
An ingredient of a propellant powder added for the purpose of retarding the deflagration of the powder in order to develop the maximum pressure in the desired location in the gun barrel, P<sup>16,19,21</sup>.

See Dinitrotoluene, FNH and NH powder.

## DIAZODINITROPHENOL (DINOL)

*Symbol:* DDNP

*Composition:*  $C_6H_2ON_2(NO_2)_2$



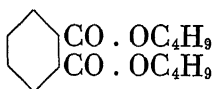
*Properties:* Bright-yellow crystals or amorphous powder or granules. Sp. gr. 1.63. Explodes when heated to a temperature of 180°. Less sensitive to impact than either lead azide or mercury fulminate, much less sensitive to friction than the latter, and does not get dead-pressed. Cannot be detonated under water with a No. 8 electric detonator. The strength (sand-bomb test) is about twice that of mercury fulminate or lead azide. The initiating power is greater than

that of mercury fulminate and similar to that of lead azide.<sup>6</sup>

*Uses:* In commercial blasting caps and as a substitute for mercury fulminate.

## DIBUTYL PHTHALATE

*Composition:*  $C_6H_4(COOC_4H_9)_2$



*Properties:* Colorless oily liquid. Sp. gr. 1.05 at 20°. B. P. 340°.

*Uses:* As a plasticizer and flash-reducer in propellants. As deterrent surface-treating agent in smokeless powders, P<sup>19</sup>.

## DICHLORDIETHYL SULFIDE

See Dichlorethyl Sulfide.

## DICHLORDIVINYLCHLORARSINE

See Vinylchlorarsine.

## DICHLORETHYL SULFIDE (DICHLOROETHYL SULFIDE) (DICHLORDIETHYL SULFIDE)

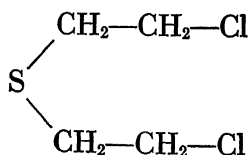
Chemical Warfare Symbol: HS

American and British: Mustard Gas

French: Yperite

German: Gelb Kreuz (Yellow Cross)

*Composition:*  $\text{Cl}(\text{CH}_2)_2\text{S}(\text{CH}_2)_2\text{Cl}$



*Properties:* Oily liquid, having an odor like mustard, garlic, or horse radish. M. P. 13.5°. B. P. 215.5°. Readily soluble in fatty oils and lipoids. In liquid and gaseous state it readily penetrates clothing and leather. In presence of water it undergoes hydrolysis, and it is easily decomposed by bleaching powder and Chloramine-T. Powerful vesicant (blister-producer); very persistent, causing eye irritation, conjunctivitis, and inflammation of respiratory tract which may lead to pneumonia.

*Uses:* Was first used in World War I by the Germans near Ypres in July, 1917, and was later produced in France and in the U. S. Was the most efficacious war gas used during the war.

*Protection:* Gas mask and full protective clothing.

*Field neutralization:* Bleaching powder; 3 per cent sodium sulfide solution ( $\text{Na}_2\text{S}$ ); bury under moist earth.

#### DICK

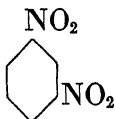
See Ethyldichlorarsine.

#### DIETHYLDIPHENYLUREA

See Diphenyldiethylurea.

#### DINITROBENZENE (*m*-DINITROBENZENE)

*Composition:*  $\text{C}_6\text{H}_4(\text{NO}_2)_2$



*Properties:* Yellowish crystals. M. P. 90°. B. P. 302°. Toxic.

*Uses:* In bursting charges for shells in mixtures with more powerful explosives or with an oxygen-carrier.

In mixture with ammonium nitrate for industrial explosives.

See Bellite, Tonite, Roburite.

## DINITROCELLULOSE

*Composition:*  $C_6H_8O_3(NO_3)_2$

Based on cellulose unit,  $C_6H_{10}O_5$ .

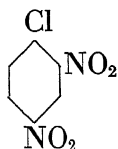
*Properties:* White matted mass. 11.11 per cent nitrogen.

*Uses:* See Collodion Cotton.

See Nitrocellulose, Tetranitrocellulose, Oktonitrocellulose.

## DINITROCHLORBENZENE (2,4-DINITROCHLORBENZENE)

*Composition:*  $C_6H_3(NO_2)_2Cl$

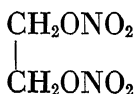


*Properties:* Yellow crystals. Sp. gr. 1.69. M. P. 52–54°. B. P. 315°.

*Uses:* Constituent of some ammonium nitrate and chlorate explosives (See).

## DINITROGLYCOL (GLYCOL DINITRATE) (ETHYLENEGLYCOL DINITRATE) (NITROGLYCOL)

*Composition:*  $(CH_2)_2(NO_3)_2$



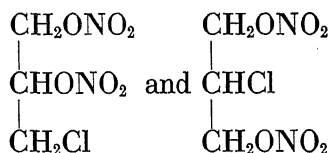
*Properties:* Slightly syrupy liquid. Sp. gr. 1.496. Behaves like nitroglycerine but is more volatile and less sensitive, a disadvantage as well as an advantage in comparison.

*Uses:* In safety and permissible explosives. In Low-Freezing Dynamite (See).

### DINITROMONOCHLORHYDRIN

*Composition:*  $C_3H_5Cl(NO_3)_2$

Mixture of 2 isomers:



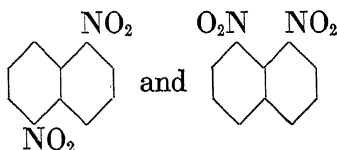
*Properties:* Colorless liquid. Sp. gr. 1.54 at 15°. Miscible with nitroglycerine.

*Uses:* In Low-Freezing Dynamite (See).

Was also used in the manufacture of safety and permissible gelatinous explosives.

### DINITRONAPHTHALENE

*Composition:* A mixture of several dinitronaphthalenes, mostly 1, 5 and 1, 8 isomers.



*Properties:* Yellow crystalline solid. M. P. about 138–140°. Weak explosive.

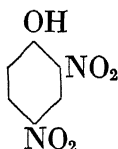


*Uses:* Was used in World War I as shell-filler in combination with ammonium nitrate (Schneiderite), also in combination with chlorates and perchlorates, and in combination with picric acid (MDN). As ingredient of permissible explosives.

See Ammonite, Schneiderite, Chlorate Explosives, MDN.

### DINITROPHENOL (2,4-DINITROPHENOL)

*Composition:*  $C_6H_3OH(NO_2)_2$



*Properties:* Yellowish crystals. Sp. gr. 1.68. M. P. 112–113°. Specification M. P. 110.5–112°.

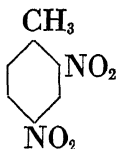
*Uses:* As component of some shell and bomb charges; for instance, in mixture with picric acid.

See Tridite, DD 60/40.

### DINITROTOLUENE (2,4-DINITROTOLUENE) (DINITROTOLUOL)

*Symbol:* DNT

*Composition:*  $CH_3C_6H_3(NO_2)_2$



*Properties:* Lemon-yellow crystals. Sp. gr. 1.32 at 15°. M. P. 70°. B. P. 300° (decomposes). Soluble in con-

centrated sulfuric acid (means of separation from TNT).

*Uses:* As an ingredient of FNH and NH smokeless powder, acting as deterrent and cooling agent, P<sup>19,20</sup>. It is also used in some permissible and chlorate explosives.

For small-grain double-base powder, P<sup>18</sup>.

As gelatinizer for propellant powders, P<sup>27</sup>.

See Cheddite, Blastine, FNH Powder, Abbcite, Di-Oil.

## DINOL

Commercial name for Diazodinitrophenol (See).

## DI-OIL (COMMERCIAL DINITROTOLUENE)

*Composition:* Composed mostly of 2,4-dinitrotoluene.

*Properties:* The crude product consists of yellow crystalline cakes or powder. M. P. 66–68°. Toxic.

*Uses:* For plastic explosives in combination with nitrates or chlorates, P<sup>39</sup>. In pulverulent dynamite, P<sup>22</sup>.

See Dinitrotoluene, Mono-Oil.

## DIPHENYLAMINE

*Composition:*  $(C_6H_5)_2NH$



*Properties:* Grayish to pale-yellow crystals. Sp. gr. 1.16 at 20°. M. P. 53°. B. P. 302°. Converted in successive stages to nitroso and nitro derivatives by action of oxides of nitrogen. This accounts for its action as a stabilizer.

*Uses:* Standard stabilizer for smokeless powder and compound propellants in the proportion of 0.8–1 per cent, P<sup>20</sup>.

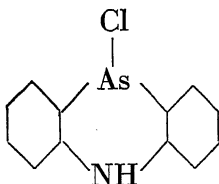
## DIPHENYLAMINEARSINE CHLORIDE

See Diphenylaminechlorarsine.

## DIPHENYLAMINECHLORARSINE (ADAMSITE) (DIPHENYLAMINEARSINE CHLORIDE) (PHENARSAZINE CHLORIDE)

Chemical Warfare Symbol: DM

*Composition:*  $(C_6H_4)_2NHAsCl$



*Properties:* Odorless, yellow crystalline solid. Sp. gr. 1.648 at 20°. M. P. 195°. Boils with decomposition at 410° under normal pressure. Corrosive to metals. A nonpersistent, very violent sternutator, similar to diphenylchlorarsine but much simpler to manufacture. Requires dust filter in gas-mask protection.

*Uses:* Particularly effective for cloud attacks. Was about ready for use by the British and American forces by the end of World War I. Also used for suppressing riots. For this purpose it is usually mixed with tear gas (chloracetophenone) and loaded in hand grenades.

*Field Neutralization:* Bleaching powder solution.

## DIPHENYLARSINE CHLORIDE

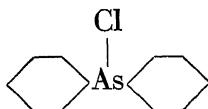
See Diphenylchlorarsine.

**DIPHENYLCHLORARSINE (DIPHENYLARSINE CHLORIDE)**

Chemical Warfare Symbol: DA

German: Blue Cross, Clark I

*Composition:*  $(C_6H_5)_2AsCl$



*Properties:* Colorless, crystalline solid when pure. M. P.  $38^{\circ}$ . B. P.  $333^{\circ}$ . If heated it forms vapors or fogs; these aerosols penetrate ordinary charcoal canisters. Needs a filter for absorption.

*Uses:* First used by Germans in September, 1917, against the Russians as a sternutator (sneeze gas), combined with Green Cross (lung irritant and vesicant). Used by spraying solutions containing it so as to obtain a fine state of subdivision in burning-type munitions. Can also be dispersed by means of high explosives, or by means of irritant gas candle.

*Protection:* Gas mask.

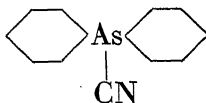
*Field neutralization:* Bleaching powder solution.

**DIPHENYLCYANARSINE (DIPHENYLARSINE CYANIDE)**

Chemical Warfare Symbol: CDA

German: Clark II

*Composition:*  $(C_6H_5)_2AsCN$



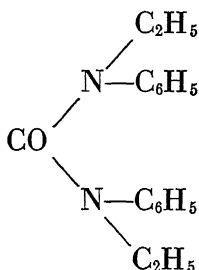
*Properties:* Colorless solid. Sp. gr. 1.45 at  $20^{\circ}$ . M. P.  $31.5^{\circ}$ . Vapor density 8.8. Boils with decomposition at  $350^{\circ}$ . Forms foggy vapors. Smells like a mixture of

bitter almonds and garlic. Extremely irritant. Requires smoke filter in gas masks.

*Uses:* Was used by the Germans in 1917 and 1918.

### DIPHENYLDIETHYLUREA (CENTRALITE I) (MOLLITE)

*Composition:*  $[\text{C}_6\text{H}_5(\text{C}_2\text{H}_5)\text{N}]_2\text{CO}$

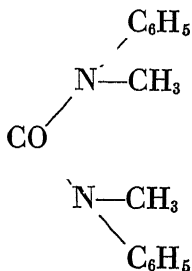


*Properties:* Almost colorless solid. M. P. 79°. Soluble in alcohol and ether. Readily converted to nitro derivatives by means of oxides of nitrogen.

*Uses:* As a stabilizer and as a deterrent for smokeless powder. To facilitate the gelatinization of collodion cotton with nitroglycerine.

### DIPHENYLDIMETHYLUREA (CENTRALITE II)

*Composition:*  $[\text{C}_6\text{H}_5(\text{CH}_3)\text{N}]_2\text{CO}$



*Properties:* Almost colorless solid. M. P. 121.5°. Soluble in alcohol and ether.

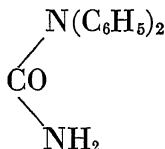
*Uses:* Same as for Diphenyldi-ethylurea (See).

## DIPHENYLENE IMIDE

See Carbazole.

## DIPHENYLUREA (ASYMMETRIC DIPHENYLUREA) (ACARDITE)

*Composition:*  $\text{NH}_2\text{CON}(\text{C}_6\text{H}_5)_2$



*Properties:* Almost colorless solid. M. P. 189°.

*Uses:* As stabilizer for smokeless powder.

## DIPHOSGENE (TRICHLOROMETHYL CHLOROFORMATE)

American: Superlite

French: Surpalite

German: Perstoff

*Composition:* Perchloromethyl formate.  $\text{ClCOOCCl}_3$ .

*Properties:* Colorless liquid of anise-like odor. Sp. gr. 1.65 at 15°. M. P. -57°. Vapor density 6.9. Volatility 26 mg/liter at 20°. B. P. 127°. Can be filled into shells in the field. In contact with air is decomposed into hydrochloric acid and carbon dioxide. Lung irritant, causes coughing and painful breathing. Toxicity about same as that of phosgene.

*Uses:* Was first used by Germans in shells at Verdun in May, 1916. Was used in combination with chloropicrin (25 per cent) to disperse the latter.

*Protection:* Gas mask.

*Field neutralization:* Alkali.

**DM**

Chemical Warfare symbol for Diphenylaminechlorarsine (See).

**DNB**

Symbol for Dinitrobenzene (See)

**DNT**

Symbol for Dinitrotoluene (See).

**DODECANITROCELLULOSE**

*Composition:*  $C_{24}H_{28}O_8(NO_3)_{12}$ . Highest degree of "nitration" theoretically possible, based on cellulose unit of  $C_{24}H_{40}O_{20}$ .

*Properties:* 14.14 per cent nitrogen. Has not been produced so far in a stable form on a large scale. The nearest to it is guncotton (13.5 per cent nitrogen). See Guncotton, Nitrocellulose.

**DOUBLE-BASE POWDERS**

*Composition:* Compound propellants containing nitrocellulose and nitroglycerine (15–40 per cent) as principal constituents. Some double-base powders also contain small percentages of potassium or barium nitrate, which salts serve the purpose of reducing flash and rendering the powder more ignitable.

*Properties:* Have greater potential than the single base powders, and a smaller weight of charge may be used to attain a specified muzzle velocity. More corrosive than single-base powders.

*Uses:* British Service Powder. Used in trench mortars, where rapid burning is required, and in high-velocity weapons (antiaircraft).

See Ballistite, Cordite, Maxim Powder.

**DUNNITE**

See Ammonium Picrate.

**DUOBEL**

A brand of nongelatinous permissible explosives manufactured by E. I. du Pont de Nemours and Co., Wilmington, Del.

See Permissible Explosives.

**DYNAMITE**

The first high explosive used for blasting purposes, invented and introduced by Alfred Nobel.

*Composition:* The original dynamite was composed of nitroglycerine, absorbed in an inert material (infusorial earth, kieselguhr; this explains the now obsolete term, Guhr Dynamite). In modern dynamites the nitroglycerine is absorbed in active, combustible materials, such as wood- or cereal meal, starch, wood pulp, etc., with addition of oxidizers (sodium or potassium nitrate) for their combustion. This increases the explosive strength as compared with a dynamite containing an inert absorbent. A small amount of an antacid is added (calcium carbonate) to neutralize any acid which may be present. Practically all commercial dynamites contain also a freezing-point depressant, such as nitroglycol. The latter has about the same explosive strength as nitroglycerine, and the mixture of the two is called explosive oil.

Only dynamites with an active base are manufactured in the U. S. Dynamites containing nitroglycerine or explosive oil, and inactive or active base are called Straight Dynamites. Commercial Straight Dynamites contain 15–60 per cent nitroglycerine or explosive oil. Example of composition for a 40 per cent Straight Dynamite:



	PER CENT
Explosive oil . . . . .	40
Sodium nitrate . . . . .	44
Antacid. . . . .	1
Carbonaceous material . . . . .	14
Moisture . . . . .	1

Special dynamites also contain ammonium nitrate, gelatinized nitroglycerine, cooling salts, etc. A relatively recent development is free-flowing dynamites. They can be poured into a vertical bore hole in the same manner as granular black powder. They have the advantage of exploding with much higher velocity and of being much safer to use because of their freedom from the hazard of ignition by sparks, P<sup>22,23</sup>.

*Properties:* The strength of Straight Dynamites is rated on the basis of percentage of nitroglycerine or explosive oil.

*Uses:* Straight dynamites are not recommended for close, underground work because of the obnoxious fumes which develop upon explosion.

For other properties and uses see Straight Dynamite, Ammonia Dynamite, Gelatine Dynamite, Low-Freezing Dynamite, Permissible Dynamite, Semigelatine Dynamite.

See also P<sup>24,33,34</sup>.

## E. C. POWDER

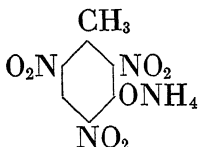
*Composition:* A smokeless powder not completely colloid and mixed with inorganic nitrates for the purpose of granulation. A nitrocellulose of approximately 13.15 per cent nitrogen is mixed with about 16 per cent of a mixture of equal parts of potassium nitrate and barium nitrate and a small amount of diphenylamine as stabilizer.

*Properties:* The granulation is regulated so that the powder will pass a 12-mesh screen and remain in a 50-mesh screen.

*Uses:* For loading blank cartridges and hand grenades.

### ECRASITE (EKRASITE)

*Composition:*  $C_6HCH_3(NO_2)_3ONH_4$ . Ammonium salt of trinitro-*m*-cresol.



*Properties:* Yellow crystals melting at about 100°.

*Uses:* Was used in Austria in combination with ammonium nitrate for large-caliber shells in World War I. See Trinitrocresol.

### ED

Chemical Warfare symbol for Ethyldichlorarsine (See).

### ENDECANITROCELLULOSE (HIGH-GRADE GUNCOTTON)

*Composition:*  $C_{24}H_{29}O_9(NO_3)_{11}$ , based on cellulose unit  $C_{24}H_{40}O_{20}$ . Represents about the highest degree of "nitration" of cellulose which is commercially available.

*Properties:* White, pulped fibers, 13.47 per cent nitrogen, soluble in acetone.

*Uses:* See Guncotton, Improved Military Rifle Powder.

### ENNEANITROCELLULOSE

*Composition:*  $C_{24}H_{31}O_{11}(NO_3)_9$ , based on cellulose unit of  $C_{24}H_{40}O_{20}$ .

*Properties:* White solid, 11.96 per cent nitrogen. Chief constituent of collodion cotton. Soluble in ether-alcohol.

*Uses:* See Nitrocellulose, Collodion Cotton.

## ETHYLARSINE DICHLORIDE

See Ethyldichlorarsine.

## ETHYLDICHLORARSINE (ETHYLDICHLOROARSINE) (ETHYLARSINE DICHLORIDE)

Chemical Warfare Symbol: ED

German: Dick

*Composition:*  $C_2H_5AsCl_2$

*Properties:* Colorless, mobile liquid; stinging, like pepper in nose. Sp. gr. 1.74 at 14°. Vapor density 6. B. P. 156°. Decomposed by water, forming ethylarsine oxide and hydrochloric acid. Lung irritant and vesicant; causes vomiting, paralysis of hands.

*Uses:* Was used by Germans in World War I in combination with Blue Cross (sternutator).

*Protection:* Gas mask and full protective clothing.

*Field neutralization:* Cover with earth, caustic soda solution.

## ETHYLENEGLYCOL DINITRATE

Correct chemical term for what is commonly called Dinitroglycol (See).

## ETHYLMONOBROMACETATE

*Composition:*  $CH_2BrCOOC_2H_5$

*Properties:* Transparent, colorless liquid. Sp. gr. 1.5 at 4°. M. P.  $-13.8^\circ$ . Vapor density 5.8. B. P.  $168^\circ$ . Slowly hydrolyzed by water.

*Uses:* As lacrimator in hand bombs for police work. Was used in 1914 by the French Army as a filler for gas-rifle grenades.

## ETHYLPICRATE

Synonym for Trinitrophenetole (See).

## EXPLOSIVE D (DUNNITE)

A high explosive developed in U. S. by Lt. Col. B. W. Dunn.

See Ammonium Picrate.

## FAVIER EXPLOSIVES

*Composition:* A group of explosives containing various combinations of ammonium nitrate and mono- or dinitronaphthalene (See). The disadvantage of this type of explosives is low sensitiveness and defective propagation.

## F8

Chemical Warfare symbol for a flare consisting of aluminum and barium nitrate.

*Uses:* For igniting incendiary containers consisting of magnesium.

## FLOWERS OF TIN

See Tin Dioxide.

## FM

Chemical Warfare symbol for Titanium Tetrachloride (See).

## FNH POWDER (FLASHLESS NON-HYGROSCOPIC POWDER)<sup>36</sup>

*Composition:* A type of smokeless powder obtained by adding to the powder base certain materials for the purpose of reducing the flash at the muzzle of the gun

and reducing the hygroscopicity of the powder. Flash reduction is achieved by cooling of the gases of combustion by the addition of substances such as mineral salts, powdered metals, esters of high boiling point, nitroguanidine, hydrocellulose, dinitrotoluene, etc. Non-hygroscopicity is achieved by incorporation of certain materials or by application of a non-hygroscopic coating (See NH Powder). The same powder may be non-hygroscopic and flashless non-hygroscopic, depending upon the gun in which it is to be used. A longer barrel, with consequent greater expansion and cooling of the gases, reduces flash. P<sup>18,19,20,21,27</sup>.

## FOG

See Silicon Tetrachloride, Titanium Tetrachloride.

## FS

Chemical Warfare symbol for Chlorsulfonic Acid-Sulfur Trioxide Solution (See).

## F STOFF

See Titanium Tetrachloride.

## FUEL OIL

See Crude Oil.

## FULMINATE OF MERCURY

See Mercury Fulminate.

## FUSE POWDER (FUZE POWDER)

*Composition:* A very fine black powder.

*Properties:* Fineness: 140-mesh or finer.

*Uses:* For safety fuses (Miner's fuse, Bickford fuse). For time-train rings and combination fuzes. (In mechanical devices the spelling is z.)

See Black Powder (With Potassium Nitrate).

## GELATINE DYNAMITE

*Composition:* Nitroglycerine, gelatinized with 2–6 per cent of collodion cotton, is absorbed in a vegetable meal for the purpose of tempering its action, with addition of enough saltpeter or other nitrates to burn the wood meal completely. The mixture of meal and nitrates is called the dope. It may also contain a small amount of antacid. Composed of 45–65 per cent blasting gelatine and 55–35 per cent mixed dope.

Example:

	PER CENT
Nitroglycerine . . . . .	62.5
Collodion cotton . . . . .	2.5
Saltpeter . . . . .	27.0
Wood meal . . . . .	8.0

In some types of gelatine dynamite the voluminous wood meal is replaced wholly or in part by heavier materials, such as aromatic nitro compounds; and in other types the saltpeter is replaced by a perchlorate, which decomposes more easily and is denser.

Example:

	PER CENT
Nitroglycerine . . . . .	36
Nitrocellulose . . . . .	2
Vegetable meal . . . . .	2
Nitro compounds of toluene, naphthalene, or diphenyl- amine . . . . .	8
Nitrates and/or perchlorates . .	52

As nitro compounds of toluene the low-melting drip oils from TNT manufacture containing di- and trinitrotoluenes may be used.

*Properties:* Waterproof and plastic; can be loaded solidly in bore holes. Does not evolve much poisonous gas on detonation, and is therefore suitable for underground work.

Strength from 20–90 per cent.

*Uses:* Most effective in hard, tight work, in operation where a maximum shattering effect is desired, and also in varieties of wet work and submarine blasting.

## GEL-COALITE

A brand of gelatinous permissible explosives manufactured by Atlas Powder Co., Wilmington, Del.

See Permissible Explosives.

## GELIGNITE

*Composition:* A type of nitroglycerine explosive, containing for example:

	PER CENT
Ammonium nitrate . . . . .	70
Nitroglycerine . . . . .	29.3
Gelatinized with	
Nitrocotton . . . . .	0.7

*Uses:* As initiator for less sensitive explosives, such as Ammonal. Also for blasting.<sup>1</sup>

## GENITE A

A brand of nongelatinous permissible explosives manufactured by American Cyanamide and Chemical Corporation, New York, N. Y.

See Permissible Explosives.

## GIANT LOW-FLAME POWDER

*Composition:* A type of American permissible dynamite similar in composition, properties, and uses to Grisoutite (See).

## GLASS POWDER

Finely powdered glass, used in percussion-cap compositions, P<sup>30</sup>.

## GLMITE

*Composition:* Mixture of liquid oxygen and carbon.

*Properties:* Effective as explosive for short time period only because of vaporization of liquid oxygen.

*Uses:* Was tried as a drop-bomb charge.<sup>7</sup>

See Liquid Oxygen Explosives.

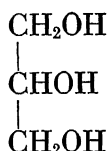
## GLUE

*Composition and Properties* vary with the source from which the glue is obtained (animal, vegetable).

*Uses:* As binder for pyrotechnic compositions such as smoke candles.

## GLYCEROL (GLYCERINE) (TRIHIDROXYPROPANE)

*Composition:*  $C_3H_5(OH)_3$



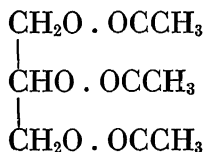
*Properties:* Colorless, syrupy liquid. Sp. gr. 1.26 at 20°. M. P. 18°. Solidifies at much lower temperature. B. P. about 290°, with slight decomposition. Miscible with water.

*Uses:* In pads for gas protection.

See Sodium Thiosulfate, Phenate-Hexamine.

## GLYCERYL TRIACETATE (TRIACETIN)

*Composition:*  $C_3H_5(CO_2CH_3)_3$





*Properties:* Colorless liquid. Sp. gr. 1.16 at 20°. M. P. -78°. B. P. 258-260°. Soluble in 14 parts water; soluble in alcohol, ether, etc.

*Uses:* As deterrent in propellant compositions, P<sup>21</sup>.

## GLYCERYL TRINITRATE, GLYCEROL TRINITRATE

Correct chemical term for the explosive commonly called nitroglycerine (See).

## GRAPHITE

*Composition:* A naturally occurring, more or less impure form of native carbon. It is now also made artificially from other forms of carbon.

*Properties:* Gray or black flakes or powder. Sp. gr. 2.2. Hardness 1-2.

*Uses:* Grade A graphite (artificial) is intended for use as a glazing agent for smokeless powder. Graphite coating is applied to promote ease in pouring grains and to prevent the collection of electrostatic charges. Blasting Powder B is coated with graphite for protection from moisture. Grade B graphite (natural) is intended for use as a binder and lubricant in pelleting explosives.

## GREEN CROSS 3

See Ethyldichlorarsine.

## GRENITE

A nitrostarch explosive.

*Composition:*

	PER CENT
Nitrostarch . . . . .	95.5-98
Petroleum oil. . . . .	0.8- 2
Gum arabic . . . . .	0.8- 2
Moisture . . . . .	0.0- 1

*Properties:* White granules. Less sensitive than straight nitrostarch.

*Uses:* Was used in World War I for grenades only, and was considered too sensitive as a trench-mortar shell explosive.

See Nitrostarch.

## GRISOU-DYNAMITE-COUCHE

A French Permissible Explosive.

*Composition:*

	PER CENT
Nitroglycerine . . . . .	12.0
Collodion Cotton . . . . .	0.5
Ammonium nitrate . . . . .	82.5
Potassium nitrate . . . . .	5.0

*Properties and Uses:* See Permissible Explosives.

## GRISOUNITE

*Composition:* Dynamites and safety explosives containing nitrated naphthalenes or toluenes in combination with ammonium nitrate (France).

## GRISOUTITE (GRISOUTINE)

*Composition:* A type of the earlier French and Belgian permissible dynamites containing, for example:

	PER CENT
Nitroglycerine . . . . .	42
Magnesium sulfate . . . . .	46
Wood meal or kieselguhr . . . . .	12

*Properties:* The water of crystallization of the magnesium sulfate is vaporized on explosion and cools the gases.

See Magnesium Sulfate.

*Uses:* For blasting in coal mines. Similar American permissible dynamites were called Giant Low-Flame Powder, "Hydrated Explosives" (See).

**GUANIDINE NITRATE**

*Composition:*  $\text{H}_2\text{NC}(\text{NH})\text{NH}_2\text{HNO}_3$

*Properties:* White granules. M. P. 206–212°. Stable, non-hygroscopic, and flashless.

*Uses:* In combination with charcoal and nitrates as blasting explosive, P<sup>15</sup>.

**GUANIDINE PICRATE**

*Composition:*  $\text{H}_2\text{NC}(\text{NH})\text{NH}_2\text{C}_6\text{H}_2(\text{NO}_2)_3\text{OH}$ .

*Properties:* Yellow crystals. Melts with decomposition above 300°. Detonation rate ( $d = 1.50$ ) 6500 m/sec. Extremely insensitive to blow and to shock (even less sensitive than ammonium picrate).

*Uses:* For armor-piercing shells.

**GUM ARABIC (ACACIA GUM)**

*Properties:* Yellowish solid, slowly soluble in two parts of water.

*Uses:* As binder in pyrotechnic compositions (smokes).

**GUNCOTTON**

*Composition:* Cellulose nitrate of high "nitration."

*Properties:* White, pulped fibers, having a nitrogen content of 13.2–13.5 per cent, only partly soluble in ether-alcohol, completely soluble in acetone. Deteriorates under heat, but is stable in moist condition. In fiber form it is a high explosive; gelatinized, it is a low-order explosive. The dry fiber can be detonated with mercury fulminate. Dry guncotton can be used as initiator for the detonation of wet guncotton. Rate of detonation (13 per cent nitrogen) 6300 m/sec. ( $d = 1.7$ ).

*Uses:* In uncolloided form as flame carrier in central tube of shrapnel shell to connect the fuze with the base charge of black powder. Formerly the principal charge for torpedo war heads and sea mines, now being replaced by TNT. In colloided form in the manufacture of high-grade smokeless powder, in mixture with pyro-cotton (See).

See Cellulose Nitrate, Smokeless Powder, Dodekanitro-cellulose, Hexanitrocellulose. Trinitrocellulose.

## GUNPOWDER

Composed of potassium nitrate, charcoal, and sulfur. Had been for 550 years the only military explosive available as a propellant; now replaced by smokeless powder. For properties and present military and industrial uses, see Black Powder (With Potassium Nitrate), Blasting Powder A.

## HARASSING AGENTS

Irritant warfare agents, including Lacrimators, Sternutators, and Irritant Smokes (See).

## HC MIXTURE

Chemical Warfare Symbol: HC

*Composition:* A smoke mixture containing zinc dust, hexachlorethane, ammonium perchlorate, ammonium chloride, and calcium carbonate.

*Properties:* On ignition, reaction between zinc dust and hexachlorethane produces zinc chloride and free carbon, both of which pass off in the smoke. The ammonium perchlorate keeps the reaction going, ammonium chloride readily volatilizes and controls the rate of burning, and calcium carbonate stabilizes the mixture by taking up any hydrochloric acid which may be present. The smoke is harmless.

*Uses:* As a screening smoke in burning type of munitions (grenades, candles, smoke pots, smoke floats, special air bombs).

See Zinc Dust, Hexachlorethane.

## H. E.

Abbreviation for High Explosives (See).

## HELIUM

*Symbol:* He

*Properties:* Colorless, inert gas. Liquefies at  $-269^{\circ}$ . Nonexplosive, noninflammable, twice as heavy as hydrogen.

*Uses:* For filling dirigibles and observation balloons.

## HERCOAL

A brand of nongelatinous permissible explosives manufactured by Hercules Powder Co., Wilmington, Del.

See Permissible Explosives.

## HERCOGEL

A brand of gelatinous permissible explosives manufactured by Hercules Powder Co., Wilmington, Del.

See Permissible Explosives.

## HEXACHLORETHANE

*Composition:*  $C_2Cl_6$ .

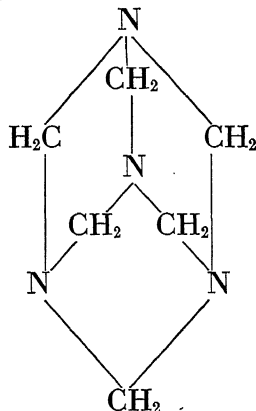
*Properties:* White crystals. Sp. gr. 2.09. M. P.  $185^{\circ}$ . Sublimes  $183-185^{\circ}$ .

*Uses:* In smoke bombs.

See Zinc Dust.

# HEXAMETHYLENE TETRAMINE (METHENAMINE) (URO-TROPINE)

*Composition:*  $(\text{CH}_2)_6\text{N}_4$



*Properties:* Colorless crystals or white powder having irritating action on the skin. Sublimes at 263°. Readily takes fire in contact with a flame. Soluble in water.

*Uses:* In compositions for protection against phosgene gas. In incendiary compositions.<sup>22</sup>

See Phenate Hexamine.

## HEXAMETHYLENE TRIPEROXIDE DIAMINE

*Symbol:* HMDT

*Composition:*  $[\text{N}(\text{CH}_2\text{O}_2\text{CH}_2)_3\text{N}]$

*Uses:* In detonator compositions.

## HEXAMINE

See Hexanitrodiphenylamine.

## HEXANITROCELLULOSE

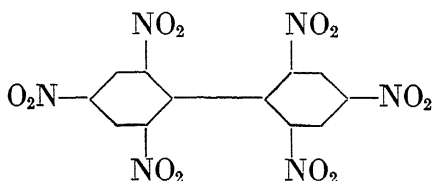
*Composition:*  $\text{C}_{12}\text{H}_{14}\text{O}_4(\text{NO}_3)_6$ . Highest degree of "nitration" theoretically possible, based on cellulose unit of  $\text{C}_{12}\text{H}_{20}\text{O}_{10}$ .

*Properties:* 14.14 per cent nitrogen.

*Uses:* Not produced in stable form; the nearest commercial product is guncotton of 13.5 per cent nitrogen. See Nitrocellulose.

## HEXANITRODIPHENYL

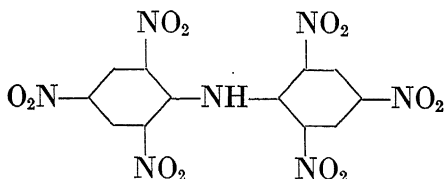
*Composition:*  $(\text{O}_2\text{N})_3\text{C}_6\text{H}_2 \cdot \text{C}_6\text{H}_2(\text{NO}_2)_3$



*Uses:* In detonating compositions.

## HEXANITRODIPHENYLAMINE (HEXIL, HEXITE, HEXAMINE)

*Composition:*  $(\text{O}_2\text{N})_3\text{C}_6\text{H}_2 \cdot \text{NH} \cdot \text{C}_6\text{H}_2(\text{NO}_2)_3$



*Properties:* Yellow needles, melts with decomposition above  $238^\circ$ .

Rate of detonation ( $d = 1.58$ ) 6900 m/sec.

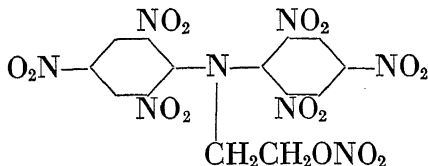
“ ( $d = 1.67$ ) 7150 m/sec.

Satisfactory as a booster explosive; for this purpose it is superior to TNT but somewhat inferior to Tetryl. Hexil is extremely stable and safer to handle than Tetryl.<sup>12</sup> Toxic.

*Uses:* As booster; perhaps also in bursting charges (in Germany).

## HEXANITRODIPHENYLAMINOETHYLNITRATE

*Composition:*  $[\text{C}_6\text{H}_2(\text{NO}_2)_3]_2\text{N}(\text{CH}_2)_2\text{ONO}_2$

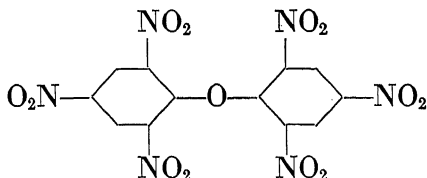


*Properties:* Yellow crystals. Sp. gr. 1.69. When rapidly heated it ignites at 390–400°. Slightly less sensitive to impact than Tetryl or Pentryl, but about same sensitivity to detonation. About same explosive strength as Tetryl, 20 per cent greater than that of TNT. The addition of an oxygen-bearing salt, such as potassium chlorate, enhances its explosive strength.<sup>26</sup>

*Uses:* Possible uses same as for Tetryl, as a booster or as a component of reinforced detonators.

## HEXANITRODIPHENYLOXIDE

*Composition:*  $(\text{O}_2\text{N})_3\text{C}_6\text{H}_2\text{OC}_6\text{H}_2(\text{NO}_2)_3$

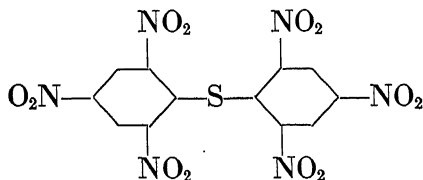


*Properties:* White plates. M. P. 269°. It is stable, has very low sensitivity, and is more powerful than picric acid.

*Uses:* In detonating compositions.

## HEXANITRODIPHENYL SULFIDE (PICRYL SULFIDE)

*Composition:*  $(\text{O}_2\text{N})_3\text{C}_6\text{H}_2\text{SC}_6\text{H}_2(\text{NO}_2)_3$



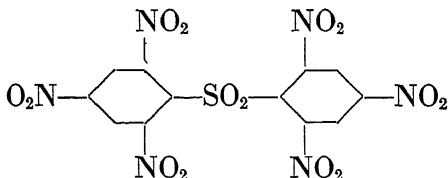


*Properties:* Golden-yellow leaflets. M. P. 234°. Powerful explosive. The explosion gases contain irritating sulfur dioxide.

*Uses:* During World War I, the Germans used drop bombs containing mixtures of TNT or trinitroanisole and hexanitrodiphenyl sulfide. It is also suitable for detonating compositions.

### HEXANITRODIPHENYL SULFONE

*Composition:*  $(\text{O}_2\text{N})_3\text{C}_6\text{H}_2\text{SO}_2\text{C}_6\text{H}_2(\text{NO}_2)_3$



*Properties:* Yellowish crystals. M. P. 307°. Stable and very powerful explosive.

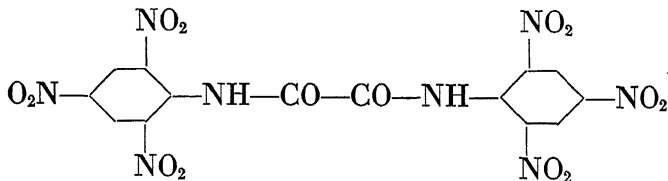
*Uses:* In detonating compositions.

### HEXANITROMANNITE (HEXANITROMANNITOL)

See Mannitol Hexanitrate.

### HEXANITRO-OXANILIDE

*Composition:*  $(\text{O}_2\text{N})_3\text{C}_6\text{H}_2(\text{NHCO})_2\text{C}_6\text{H}_2(\text{NO}_2)_3$



*Properties:* Yellow solid, melting at about 300°. Is about as powerful as TNT.

*Uses:* Could be used as a shell-filler.

**HEXIL**

See Hexanitrodiphenylamine.

**HEXITE**

See Hexanitrodiphenylamine.

**HEXOGEN**

See Trimethylene Trinitramine.

**HEXONE T-4**

See Trimethylene Trinitramine.

**HEXONIT**

*Composition:* A mixture of nitroglycerine, Penthrite, and Trimethylene Trinitramine containing at least 10 per cent of the latter.

*Properties:* One of the most powerful high explosives.<sup>27</sup>

**HEXYL**

See Hexanitrodiphenylamine.

**HIGH EXPLOSIVES (H. E.)**

In high explosives explosion proceeds with extreme rapidity and is transmitted practically instantaneously throughout the mass. This is called detonation, or high-order explosion, to differentiate it from low-order explosion, such as rapid combustion of propellants. High explosives are not only characterized by their rapidity of chemical transformation but also by the great amount of energy released. High explosives differ greatly in sensitivity. High explosives which are sensitive to flame, heat, or shock are in a class by themselves; they are called primary explosives because they are used to initiate the detonation of less

sensitive high explosives. The latter are used as bursting charges for shells, bombs, mines, and torpedoes; and it is these that are generally known as high explosives. This group includes picric acid and trinitrotoluene. The latter is the most generally satisfactory high explosive and is universally used except for armor-piercing shells. It is, however, not readily detonated by mercury fulminate, or it would require too large an amount of this sensitive initiator for complete detonation. Accordingly, a more sensitive high explosive, a booster, is incorporated in the train of explosives between the detonator and the bursting charge. The standard booster explosive is Tetryl.

*Composition:* See Trinitrotoluene, Trinitrophenol, Tetryl, Nitroglycerine, Ammonium Picrate, Amatol, Dynamite, Penthrite, Cyclonite.

*Properties:* The high explosives do not function by burning; they detonate at very high velocity, 3000–9000 m/sec. They are not readily detonated by heat, flame, or shock. Their detonation is initiated under the influence of the shock of an exploding primary explosive. Their detonation results in almost instantaneous molecular rearrangement, usually with formation of a large volume of hot gases, such as carbon monoxide, carbon dioxide, hydrogen, methane, nitrogen, etc. The explosive strength depends upon the quantity of gas and heat produced, whereas the shattering power (brisance) is dependent on the velocity of the reaction and is indicated by the rate of detonation. The latter is affected somewhat by the degree of confinement, but not to the same extent as in the case of the low explosives.

*Uses:* As bursting charge for shells, bombs, torpedo war heads, and mines. As component of blasting explosives. Some of the more sensitive H. E. are used as boosters in detonating compositions.

**HIGH-GRADE GUNCOTTON**

See Nitrocellulose, Endecanitrocellulose.

**HMTD**

Symbol for Hexamethylene Triperoxide Diamine (See).

**HNM**

Symbol for Hexanitromannitol.

See Mannitol Hexanitate.

**HS**

Chemical Warfare symbol for Dichlorethyl Sulfide (See).

**"HYDRATED EXPLOSIVES"**

*Composition:* A type of American permissible explosives containing various percentages of salts with water of crystallization, such as Magnesium Sulfate,  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ . For *Properties* and *Uses*, see Grisou-tite, Magnesium Sulfate, Permissible Dynamites.

**HYDRATED LIME (CALCIUM HYDROXIDE)**

*Composition:*  $\text{Ca}(\text{OH})_2$

*Properties:* White granules or powder. Sp. gr. 2.34. Absorbs acid gases.

*Uses:* In gas masks.

See Soda Lime.

**HYDROCYANIC ACID**

*Composition:*  $\text{HCN}$

*Properties:* Colorless gas. Liquid below  $26^\circ$ . Lighter than air, therefore difficult to obtain heavy concentration under field conditions. Systemic poison. Tends to polymerize.

*Uses:* Was used by the French in chemical shells, mixed with other products (because of high volatility and to prevent polymerization).

See Vincennite.

## HYPO

Trade name for Sodium Thiosulfate (See).

## IMPROVED MILITARY RIFLE POWDER (I. M. R. POWDER)

*Composition:* An extruded powder prepared from two types of nitrocellulose, blended to give average nitrogen content of 13.15 per cent and a solubility in ether-alcohol of 40 per cent or greater. Components: Pyro-cotton,  $12.6 \pm 0.1$  per cent; Guncotton, 13.2 per cent or greater.

## I. M. R. POWDER

See Improved Military Rifle Powder.

## INCENDIARIES<sup>16</sup>

Chemical agents which cause ignition of combustible substances by flame or generation of heat. They also may cause casualties if they come in contact with the human body.

See Magnesium, Phosphorus White, Thermit, Crude Oil, Solid Oil.

## INDEPENDENT

A brand of nongelatinous permissible explosives manufactured by Independent Explosive Company of Pennsylvania, Pittsburgh, Pa.

See Permissible Explosives.

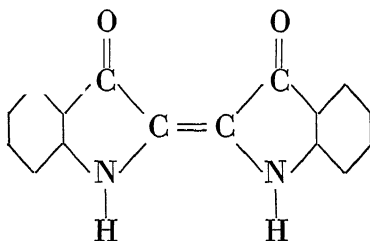
## INDEPENDENT-GEL

A brand of gelatinous permissible explosives manufactured by Independent Explosive Company, Pittsburgh, Pa.

See Permissible Explosives.

## INDIGO

*Composition:*  $C_{16}H_{10}O_2N_2$



*Properties:* Dark blue, lustrous powder. Can be sublimed. Sublimes at  $300^{\circ}$ , decomposes at  $392^{\circ}$ .

*Uses:* To produce blue-colored smoke for military signaling, from shells, rockets, or pots. To produce green-colored smoke in mixtures with Auramine.

## INDURITE

*Composition:* A smokeless powder, formerly used in the U. S., consisting of 40 per cent guncotton, colloided with 60 per cent nitrobenzene.

## INFUSORIAL EARTH (KIESELGUHR) (DIATOMITE)

*Composition:* A siliceous earth, consisting of diatoms.

*Properties:* Whitish powder, resistant to heat and chemical action, absorbs liquids readily. Sp. gr. calcined 0.34.

*Uses:* As an absorbent in the manufacture of explosives.

See Dynamite.

Provides porosity in gas-mask material.

See Soda Lime.

## INITIATORS

See Primary Explosives.

## IRON OXIDE

*Composition:*  $\text{Fe}_2\text{O}_3$

*Properties:* Reddish-brown, heavy, amorphous powder. Sp. gr. 5.12–5.24. M. P.  $1560^\circ$ .

*Uses:* As component of incendiary mixtures.

See Thermit.

## IRRITANT SMOKE

A sternutator type of irritant chemical agent that can be disseminated in the air as extremely small solid or liquid particles.

See Diphenylaminechlorarsine, Diphenylchlorarsine.

## KIESELGUHR

See Infusorial Earth.

## KING, KING SPECIAL

Brands of nongelatinous permissible explosives manufactured by King Powder Co., Cincinnati, O.

See Permissible Explosives.

## KJ

British symbol for Tin Tetrachloride (See).

## KLOP

German symbol for Chlorpicrin (See).

LACRIMATORS (TEAR GASES)<sup>16</sup>

Harassing agents causing copious flow of tears and intense eye irritation.

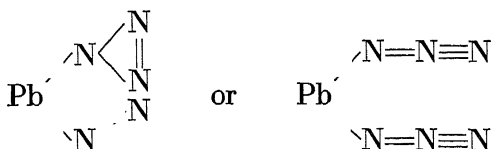
See Chloracetone, Bromacetone, Brombenzylcyanide, Chloracetophenone, Chlorpicrin.

## L. E.

See Low Explosives.

## LEAD AZIDE

*Composition:*  $\text{PbN}_6$ .



It is one of the few commercially produced explosives which do not contain oxygen.

*Properties:* White to buff-colored crystalline powder. Sp. gr. 4.80. One of the most stable initiators. Less sensitive to blows than mercury fulminate. Too insensitive to be used alone where initiation is by impact of firing pin. Not easily decomposed by heat. Instantaneous flash point over  $350^\circ$ . Forms a supersensitive explosive in contact with copper.

*Uses:* In loading fuze detonators and in the manufacture of priming compositions. Substitute for mercury fulminate. On account of its high temperature of ignition, lead azide is not easily ignited by the spit of a safety fuse. Adding lead styphnate, which is more readily ignited, overcomes the difficulty. It is loaded into detonators made of aluminum.<sup>10</sup> It is also used in detonating rivets, with addition of silver acetylide or tetracene to lower the ignition temperature,  $P^{7,8}$ .



**LEAD NITRATE**

*Composition:*  $\text{Pb}(\text{NO}_3)_2$

*Properties:* White crystals. Sp. gr. 4.53. Does not melt. Decomposes above  $205^\circ$ . In contact with organic matter promotes combustion.

*Uses:* As oxidizing agent in percussion priming compositions.

**LEAD PEROXIDE (LEAD DIOXIDE)**

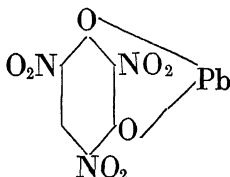
*Composition:*  $\text{PbO}_2$

*Properties:* Brown powder. Sp. gr. 9.38. Evolves oxygen when heated. Powerful oxidizing agent.

*Uses:* As oxidizing agent in detonating compositions.

**LEAD STYPHNATE**

*Composition:* Lead Trinitroresorcinate, Lead Salt of Styphnic Acid.  $\text{C}_6\text{H}(\text{NO}_2)_3(\text{O}_2\text{Pb})$



*Properties:* Explosion temperature  $310^\circ$ .

*Uses:* In commercial priming compositions and blasting caps. In combination with lead azide to facilitate its ignition.

**LEAD SULFOCYANATE (LEAD THIOCYANATE)**

*Composition:*  $\text{Pb}(\text{CNS})_2$

*Properties:* White crystals. Sp. gr. 3.82. Decomposes at  $190^\circ$ .

*Uses:* As fuel component in percussion primer compositions, P<sup>430,36</sup>.

**LEWISITE**

A powerful chemical warfare agent, named after W. Lee Lewis, its American discoverer.

See Chlorvinylidichlorarsine.

**L. F. DYNAMITE**

Commercial designation for Low-Freezing Dynamite (See).

**LIBERTY-GEL**

A brand of gelatinous permissible explosives manufactured by Liberty Powder Co., Pittsburgh, Pa.

See Permissible Explosives.

**LINSEED OIL**

*Composition:* Glycerides of various saturated and unsaturated fatty acids.

*Properties:* Yellowish oil, gradually thickens on exposure to air. Sp. gr. 0.93.

*Uses:* For coating magnesium particles which are to be used for pyrotechnic purposes, as a protection from moisture, P<sup>2</sup>.

**LIQUID OXYGEN**

*Symbol:* O<sub>2</sub>

*Properties:* Colorless or slightly bluish liquid. B. P. -183°. Since it cannot exist at ordinary temperature, it must be given a chance to evaporate when used in explosive mixtures. Gradual evaporation of the oxygen maintains the required low temperature to keep it in liquid form; the explosive strength diminishes as the oxygen evaporates. Liquid-oxygen explosives, therefore, have a short life and must be prepared at the point of consumption.

*Uses:* As blasting explosive in mixture with combustible absorbent materials. Cannot be used in bombs.<sup>7</sup>  
See Liquid-Oxygen Explosives.

### LIQUID-OXYGEN EXPLOSIVES (L. O. X.)

*Composition:* They consist of an absorbent carbonaceous material in a canvas wrapper soaked with liquid oxygen.

*Properties:* They are highly inflammable, and inflammation may be followed by detonation. This hazard may be reduced by addition of fire-retarding substances such as phosphoric acid. The cartridges are fired with cap or electric detonators, or cordeau, in much the same way as other blasting explosives.

*Uses:* For quarrying, strip mining, and open-cut ore mining. Use underground or in confined places is not recommended by U. S. Bureau of Mines because of large percentage of carbon monoxide in the explosion gases.

See Liquid Oxygen.

### LOW EXPLOSIVES (L. E.)

See Propellants.

### LOW-FREEZING DYNAMITE (L. F. DYNAMITE)

*Composition:* Dynamite with addition products to lower the freezing point of the nitroglycerine.

Addition products: Dinitromonochlorhydrin

Dinitroglycol

Tetranitrodiglycerine

*Properties:* The addition products prevent the solidification of the nitroglycerine at low temperatures. All dynamites produced in the U. S. are now low-freezing; they will not freeze under exposure to such atmos-

pheric temperatures as may be met with in this country.

*Uses:* See Dynamite.

#### L. O. X.

See Liquid-Oxygen Explosives.

#### LUNG IRRITANTS (TOXIC SUFFOCANTS) <sup>16</sup>

Chemical agents whose physiological action is limited to the respiratory tract, causing irritation and inflammation of bronchial tubes and lungs.

See Chlorine, Phosgene, Diphosgene, Chlorpicrin, Ethyldichlorarsine.

#### LYDDITE

British term for picric acid.

*Composition:* A series of high explosives composed principally of picric acid, usually with about 10 per cent of other aromatic nitro compounds added to it for the purpose of lowering the melting point to a safe range for shell-loading.

See Trinitrophenol.

#### M-1

Chemical Warfare symbol for Chlorvinyldichlorarsine (See).

#### MAGNESIUM

Symbol: Mg

*Properties:* Silver-white, lustrous, malleable metal. Sp. gr. 1.74. M. P. 650°. B. P. 1120°. In powdered or flake form it burns readily with a brilliant, bluish-white light and with evolution of great heat of combustion. Powder liberates hydrogen when in contact with water.

*Uses:* In tracer powder ( $P^2$ ) and in incendiary shells, also as casing of incendiary bombs.<sup>8</sup> For pyrotechnic purposes for the production of dazzling white light and for use in colored fires, for signaling, and for illuminating landing fields,  $P^{2,3}$ .

## MAGNESIUM CARBONATE

*Composition:*  $MgCO_3$ . Found as mineral (Magnesite).

*Properties:* Very light, white powder.

*Uses:* As antacid in dynamites.

See Dynamite, Super Excellite.

## MAGNESIUM FLARES

*Composition:* Mixtures of potassium perchlorate or barium and strontium nitrate with magnesium powder or flakes,  $P^2$ .

*Properties and Uses:* In aviation for signaling and for illuminating landing fields and military objectives.

See Aluminum Flares.

## MAGNESIUM SULFATE

*Composition:*  $MgSO_4 \cdot 7H_2O$

*Properties:* Colorless crystals. Sp. gr. 1.678.

When incorporated into safety explosives, the water of crystallization and the steam resulting from it have the effect of cooling the explosion gases.

*Uses:* In the earlier types of safety explosives.

See Grisoutite, Giant Low-Flame Powder, "Hydrated Explosives."

## MAGNETITE (MAGNETIC IRON OXIDE)

*Composition:* Mineral consisting mostly of  $Fe_3O_4$ .

*Properties:* Black crystalline powder. Sp. gr. 5-5.4. M. P. 1538°. Magnetic.

*Uses:* As component of incendiary mixtures.  
See Thermit.

## MAIZE STARCH

Component of granular detonating blasting explosives, P<sup>33</sup>.

## MANGANESE DIOXIDE (MANGANESE PEROXIDE) (MINERAL FORM, PYROLUSITE)

*Composition:*  $\text{MnO}_2$

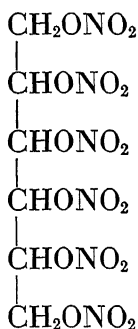
*Properties:* Brown or black powder. Sp. gr. 5.03.  
Oxygen carrier. Decomposes on heating.

*Uses:* In detonating compositions and for pyrotechnic purposes.

## MANNITOL HEXANITRATE (HEXA NITROMANNITE)

*Symbol:* HNM

*Composition:*  $\text{CH}_2\text{NO}_3(\text{CHNO}_3)_4\text{CH}_2\text{NO}_3$



*Properties:* Colorless crystals or white powder. M. P. 112–113°. Sp. gr. 1.604. Soluble in ether and hot alcohol.

*Uses:* As a substitute for mercury fulminate in priming compositions for percussion caps. Used in combination with tetracene for explosive charges of detonating rivets, P<sup>9,10</sup>.

**MARTONITE**

French term for a Bromacetone composition (See Bromacetone).

*Composition:*

	PER CENT
Bromacetone . . . . .	80
Chloracetone . . . . .	20

**"MAUGUINITE"**

French term for Cyanogen Chloride (See).

**MAXIM POWDER**

*Composition:* A double-base powder composed of both soluble and insoluble nitrocellulose, nitroglycerine, and castor oil.

**MD**

Chemical Warfare symbol for Methylchlorarsine.

**MDN**

*Composition:* A mixture of 1 part dinitronaphthalene and 4 parts picric acid.

*Properties:* Yellow crystalline mass. Melting point between 105° and 110°.

*Uses:* As bursting charge. The dinitronaphthalene is added to the picric acid for the purpose of lowering the melting point of the latter for shell-loading.

**MDPC**

A French mixture of high explosives.

*Composition:*

	PER CENT
Picric acid . . . . .	55
Dinitrophenol . . . . .	35
Trinitrocresol . . . . .	10

*Properties:* Melts between 80° and 90°.

*Uses:* As bursting charge. The dinitrophenol and trinitrocresol are added to the picric acid for the purpose of lowering the melting point of the latter for shell-loading.

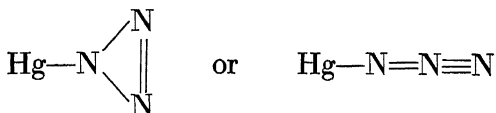
## MELINITE

French name for picric acid and a series of picric acid explosives.

See Trinitrophenol.

## MERCURY AZIDE (MERCUROUS AZIDE)

*Composition:*  $\text{HgN}_3$



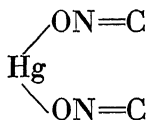
*Properties:* Claimed not to give rise to a supersensitive explosive in contact with copper, such as is the case with lead azide.

*Uses:* For initiating compositions.

## MERCURY FULMINATE

For nearly a century it has been used universally for firing propellant powders and for initiating the detonation of high explosives.

*Composition:*  $\text{Hg}(\text{ONC})_2$



*Properties:* Crystals of sparkling appearance, white, gray, or light gray with yellowish tint. Sp. gr. 4.42. M. P. explodes. Very sensitive to flame, impact, and friction when dry. Must be kept moist until used.<sup>41</sup> Be-



comes "dead-pressed" (not capable of being exploded by flame) at pressures higher than 600 kg/sq. cm. Subject to some deterioration when stored in hot climates. It detonates completely and with great violence on ignition by means of a flame such as a "spit" from a fuse or by means of an electrically heated wire.

*Uses:* As initiator or primer for bringing about the detonation of high explosives or the ignition of powder. Commonly used in combination with substances which provide a more prolonged blow and a bigger flame than mercury fulminate alone, such as potassium chlorate. In the reinforced booster type detonators, the fulminate is made more effective by a charge of a fairly sensitive and very powerful high explosive, such as Tetryl. Generally used in the manufacture of caps and detonators for initiating explosions for military, industrial, and sporting purposes.

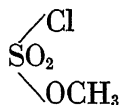
## METHENAMINE

See Hexamethylene Tetramine.

## METHYLCHLORSULFONATE (METHYLSULFURYLCHLORIDE)

German: C—Stoff

*Composition:*  $\text{CH}_3\text{OSO}_2\text{Cl}$



*Properties:* Transparent, viscid liquid. Pungent odor. Sp. gr. 1.49 at 10°. Vapor density 4.5. B. P. 133°. Lacrimates in concentration as low as 1:750,000. Decomposed by water.

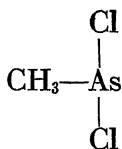
*Uses:* Of historic interest only. It was the first warfare agent to be successfully used in projectiles. The

Germans employed it in trench-mortar bombs and hand grenades in June, 1915.

### METHYLDICHLORARSINE

Chemical Warfare symbol: MD; German name: Methyldick

*Composition:*  $\text{CH}_3\text{AsCl}_2$



*Properties:* Colorless liquid. Sp. gr. 1.838 at 20°. B. P. 132°. Vapor density 5.5. Decomposed by water. Vesicant and lung irritant. Low persistency.

*Uses:* Was under investigation at the end of World War I. Appeared promising for producing rapid vapor burns in offensive activities.

### METHYL PICRATE

Synonym for Trinitroanisole (See).

### METHYLSULFURYL CHLORIDE

Synonym for Methylchlorsulfonate (See).

### METHYLTETRA-NITRANILINE

Sometimes erroneously used as chemical name for Tetryl. See Trinitrophenylmethylnitramine.

### MILITARY GUNCOTTON (M. G. C.)

*Composition:* Nitrocellulose containing 13.0–13.3 per cent nitrogen.

*Properties:* Can be plasticized with acetone, amylacetate, or nitroglycerine.

*Uses:* In gelatinized form as propellant for small arms, and in the fiber form as high explosive in contact mines. See Guncotton, Nitrocellulose.

### MINERAL JELLY (SOFT PARAFFIN) (PETROLATUM) (VASELINE) (PETROLEUM JELLY)

*Composition:* A mixture of high-boiling solid petroleum hydrocarbons (paraffin) mixed with some liquid hydrocarbons which have not been removed in the refining.

*Properties:* Semisolid, colorless or pale-yellow, translucent mass. Sp. gr. 0.82–0.86 at 60°. Melts 38–54°.

*Uses:* As component of powders and explosives to decrease sensitiveness and flash.

See Cordite, Double-Base Powders, FNH Powder.

### MINER'S FUSE

See Fuse Powder.

### MMN

*Composition:* A mixture of 3 parts mononitronaphthalene and 7 parts picric acid.

*Properties:* Very insensitive to impact. Can be cast.

*Uses:* Was used for drop bombs in World War I.

See Trinitrophenol.

### MOLLITES

Original German term for Centralites.

See Diphenyldimethylurea.

### MONOBEL

A type of permissible improved ammonium nitrate explosive, containing a small amount of nitroglycerine, used in England and U. S.

*Composition:* Example:

	PER CENT
Ammonium nitrate . . . . .	70
Nitroglycerine . . . . .	10
Common salt . . . . .	10
Rye flour . . . . .	2
Wood pulp . . . . .	8

For *Properties* and *Uses*, see Ammonium Nitrate Explosives.

## MONOBEL

A brand of nongelatinous permissible explosives manufactured by E. I. du Pont de Nemours and Co., Wilmington, Del.

See Permissible Explosives.

## MONONITROBENZENE (OIL OF MIRBANE)

See Nitrobenzene.

## MONONITRONAPHTHALENE

See Nitronaphthalene.

## MONONITROTOLUENE

See Mono-Oil.

## MONO-OIL (COMMERCIAL M. N. T.)

*Composition:* Mixture of about 62 per cent ortho-, 34 per cent para-, and 4 per cent meta-nitrotoluenes.

*Properties:* Yellow oil with pungent odor. Sp. gr. 1.16. Distills between 220–240°.

*Uses:* In low-freezing dynamites. As plasticizer for nitrocellulose. In blasting explosives in combination with chlorates or nitrates. Such plastic explosives have the desirable property of completely filling the bore hole by using only a light pressure. The oily

nitro compound also serves as a protection against dampness, and it has the advantage of being an active ingredient in comparison with paraffins and greases which have previously been used as plasticizers.

## MTTC

A French mixture of high explosives.

*Composition:*

	PER CENT
Picric acid . . . . .	55
Trinitrotoluene . . . . .	35
Dinitrophenol . . . . .	10

*Properties:* Yellow crystalline mass, melting between 80° and 90°.

*Uses:* For bursting charges. The dinitrophenol and TNT are added to lower the melting point of the picric acid in order to facilitate the shell-loading.

## MUSTARD GAS

See Dichlorethyl Sulfide.

## NAPCOGEL

A brand of gelatinous permissible explosives manufactured by National Powder Co., Eldred, Pa.

See Permissible Explosives.

## NAPHTHALENE

*Composition:*  $C_{10}H_8$



*Properties:* White scales. Sp. gr. 1.45 at 20°. M. P. 80.2°. B. P. 218°. Insoluble in water. When heated, yields inflammable vapors.

*Uses:* For producing smokes.  
See Zinc Dust.

## NAPHTHALITE

*Composition:* Dynamites and safety explosives containing nitronaphthalenes (France).

## NATIONAL

A brand of nongelatinous permissible explosives manufactured by National Powder Co., Eldred, Pa.  
See Permissible Explosives.

## NH POWDERS (NON-HYGROSCOPIC POWDERS)

The straight nitrocellulose type of powder is subject to change on storage due to volatilization of residual solvents or to absorption of moisture. Such changes affect the ballistic properties of the powders and are therefore objectionable. By addition of modifying materials powders are now being produced which are substantially nonvolatile, non-hygroscopic, and flashless. They are designated FNH if flashless, or NH if used in weapons in which flashlessness is not attained. See FNH Powders.

## NITRAMON

*Composition:* An explosive (du Pont Co. brand) containing around 92 per cent ammonium nitrate and no nitroglycerine.

*Properties:* Very insensitive to shock and characterized by an unusually high degree of safety. Its detonation requires a high-velocity primer of TNT or dynamite in addition to the initiator. Very safe to handle.

*Uses:* For blasting in wet and dry work. Blasting agent for quarries.

**NITROBENZENE (MONONITROBENZENE) (OIL OF MIRBANE)**

*Composition:*  $C_6H_5NO_2$

$NO_2$

*Properties:* Yellow oil. Sp. gr. 1.205 at 18°. M. P. 5.8°. B. P. 210.8°. Nitrobenzene alone is not an explosive, but in combination with genuine explosives it can be detonated and it then exerts a retarding effect. Toxic if its vapors are inhaled or if it is absorbed through the skin.

*Uses:* In combination with tetranitromethane.<sup>19</sup> See Indurite, Double-Base Powders, Sprengel Explosives, Bellite, Rack-a-Rock.

**NITROCELLULOSE**

Nitrocellulose is the universal basis of all propellant powders and is therefore of tremendous military importance. The development of nitrocellulose explosives covers a period of nearly one hundred years, and much further progress may be looked for.

Pélouze prepared the first nitrocellulose in 1838. Schoenbein started its promotion as an explosive in 1845. The early attempts resulted in disastrous explosions due to the instability of the manufactured product.

In 1864, Abel greatly improved the stability by alternately boiling and pulping the nitrocellulose; he also tried to control the speed of combustion of the finished explosive by compressing it. In about 1884, Schultze introduced a partially colloided nitrocellulose in combination with metallic nitrates, and at about the same

time a similar product (E. C. Powder) was introduced in England.

In 1886, Vieille placed the art of smokeless-powder manufacture on a real foundation by producing the first thoroughly colloidized nitrocellulose powder in the form of square flakes of uniform size and thickness.

In 1893, Mendeleeff introduced an improved process for the manufacture of pyrocotton. During the last two years of the World War the Germans used wood pulp as cellulosic raw material instead of cotton linters. After the war, improved flashless and non-hygroscopic powders were developed in the U. S. In recent years Olsen (Western Cartridge Co.) introduced a method which greatly simplifies the washing and stabilization operations in the process and which produces the powder in a uniform spherical form (Ball Powder).

*Composition:* Chemically, nitrocellulose is a nitric ester of cellulose and not a nitro compound. The correct chemical name, therefore, is cellulose nitrate. However, the term *nitrocellulose* has been adopted by tradition and is generally used. Nitrocellulose is not a single definite compound, but a mixture, the degree of nitration being measured by the percentage of nitrogen. The nomenclature is confusing, because in the old literature it is based on cellulose  $C_6H_{10}O_5$ , in later literature on  $C_{12}H_{20}O_{10}$ , and in the more recent on  $C_{24}H_{40}O_{20}$ . Depending on which basis is being used, the product of highest nitration would be Trinitrocellulose, Hexanitrocellulose, or Dodekanitrocellulose, respectively, all three products representing the same nitrocellulose of 14.14 per cent nitrogen. Recent practice is to designate nitrocelluloses by per cent nitrogen rather than by chemical terms, or to use commercial terms which refer to nitrocelluloses of certain percentages of nitro-



gen. The commercial products of interest in the explosive field are:

	PER CENT NITROGEN
Guncotton . . . . .	13.0 and over
Pyrocotton . . . . .	12.6
Collodion Cotton . . . . .	11.2-12.2

For approximate chemical composition, see Endekanitrocellulose, Dekanitrocellulose, Oktonitrocellulose, Enneanitrocellulose.

For *Properties* and *Uses*, see Guncotton, Pyrocotton, Collodion Cotton, Smokeless Powder, Single-Base Powder, Double-Base Powder, Ball Powder.

## NITROCHLOROFORM

Synonym for Chlorpicrin (See).

## NITROGEN DIOXIDE

*Composition:*  $\text{NO}_2$

*Properties:* Reddish-yellow gas. Vapor density 1.49. M. P.  $-9.6^\circ$ . B. P.  $21.6^\circ$ . An oxidizing gas which is easily liquefied.

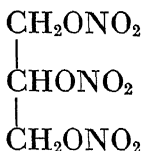
*Uses:* See Anilite.

## NITROGLYCERINE (GLYCERYL TRINITRATE) (colloq. SOUP) (BLASTING OIL)

One of the most important products in the explosives industry. For most purposes it is too sensitive to be used alone. It became the first high explosive for blasting purposes when Nobel made its use comparatively safe by absorbing it in infusorial earth (See Dynamite). It was also Nobel who provided for maximum utilization of the explosive strength of nitroglycerine by gelatinizing it with nitrocellulose (See Blasting Gelatine).

Dynamites and Blasting Gelatines form the foundation of the modern high-explosives industry, and it was again Nobel who provided for safe and satisfactory initiation of these types of explosives by invention of the Copper Capsule Mercury Fulminate detonator.

*Composition:*  $C_3H_5(ONO_2)_3$



Nitroglycerine, just as nitrocellulose, is a misnomer. The correct chemical name is glyceryl trinitrate, because the product is a nitric ester of glycerol and not a nitro derivative. However, the term *nitroglycerine* has been established by tradition and is generally used.

*Properties:* Pale-yellow, oily liquid. Colorless in pure condition. Sp. gr. 1.60 at 15°. M. P. 13°. Becomes appreciably volatile above 50°. Explosion point around 200°–260°. Rate of detonation 7450 m/sec. at  $d = 1.60$ . Soluble in most organic solvents. Slightly soluble in water. Very sensitive to shock and friction. Difficult to detonate in frozen condition. When used in dynamite, the freezing of the nitroglycerine would cause the miners to thaw out the explosive; and since they used unsuitable equipment, many fatal accidents occurred. This led to the addition of other explosive oils for the purpose of lowering the freezing point of the nitroglycerine. See Low-Freezing Dynamites. Causes severe headaches when breathed or when absorbed by the skin.

*Uses:* In dynamite, blasting gelatine, gelatine dynamite, double-base powder, permissible explosives. Also used for shooting oil wells.

**NITROGLYCERINE GELATINE**

See Blasting Gelatine.

**NITROGLYCERINE POWDERS**

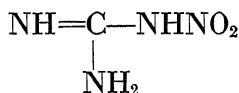
See Double-Base Powders.

**NITROGLYCOL**

Synonym for Dinitroglycol (See).

**NITROGUANIDINE**

*Composition:*  $O_2NNHC(NH)NH_2$



*Properties:* Pale needles. M. P. 230–231°. A cool and flashless explosive, about as powerful as TNT. Mixed with colloided nitrocellulose it yields a propellant powder which gives no flash from the muzzle of the gun.

*Uses:* Flashless, smokeless powder. Was used in Germany in World War I in mixture with ammonium nitrate and paraffin wax as trench-mortar ammunition. As sensitizer in perchlorate explosives, P<sup>42</sup>.

**NITROMANNITE**

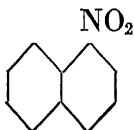
Synonym for Mannitol Hexanitrate (See).

**NITROMETHANE**

See Tetranitromethane.

**NITRONAPHTHALENE (ALPHA-NITRONAPHTHALENE)  
(MONONITRONAPHTHALENE)**

*Composition:*  $C_{10}H_7NO_2$



*Properties:* Yellow crystals. Sp. gr. 1.33. M. P. 61°. B. P. 304°. Insoluble in water. Decomposes above 300°. Becomes an explosive only when mixed with oxygen carriers such as ammonium nitrate.

*Uses:* In mixture with picric acid to reduce its melting point.

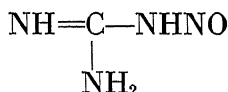
See Trimonite, MMN.

In mixture with ammonium nitrate.

See Favier Explosive.

## NITROSOGUANIDINE

*Composition:*  $\text{ONNHC}(\text{NH})\text{NH}_2$



*Properties:* Yellow powder. Decomposes without melting at 160–165°.

*Uses:* As fuel component in percussion priming compositions.

## NITROSTARCH (STARCH NITRATE)

*Composition:* Nitric ester of starch. It is not a definite, single compound, but rather a mixture of various esters of different degrees of “nitration,” measured by the percentage of nitrogen. Like nitrocellulose, nitrostarch is a nitrate and not a nitro compound; and the correct chemical name is starch nitrate. However, the term nitrostarch has been generally adopted.

*Properties:* White powder, soluble in acetone and ether-alcohol. 12.5–12.7 per cent nitrogen. Highly inflammable. Can be detonated by No. 8 commercial blasting cap. Stability on storage decreases with slightly elevated temperatures. Decomposes above 100°.

*Uses:* As ingredient of blasting explosives for quarrying, P<sup>35</sup>. Has been considered for manufacture of

smokeless propellant powder. Satisfactory as demolition explosive.<sup>21</sup>

See Trojan Explosive.

## NITROXYLENE

*Composition:* A mixture of three nitroxylenes, consisting largely of the nitro-meta-xylene.

*Properties:* Yellow oil. Sp. gr. about 1.35.

*Uses:* As gelatinizing accelerator for pyroxylin. In blasting explosives, in combination with tetranitromethane and nitrostarch, P<sup>35</sup>.

## NOVIT

*Composition:* A mixture of Hexyl (hexanitrodiphenylamine) and TNT.

## NYSOL

*Composition:* Mixture of nitronaphthalenes and nitroxylenes.

*Uses:* As freezing-point depressant in dynamite.

## OIL OF MIRBANE

Commercial name for Nitrobenzene (See).

## OCTONITROCELLULOSE

*Composition:*  $C_{24}H_{32}O_{12}(NO_3)_8$

Based on cellulose unit  $C_{24}H_{40}O_{20}$ . Represents a degree of nitration of cellulose within the range of Collodion Cotton.

*Properties:* 11.11 per cent nitrogen.

*Uses:* See Collodion Cotton.

## OPACITE

French term for Tin Tetrachloride (See).

## OXYGEN

See Liquid Oxygen.

## PARAFFIN

*Composition:* Mixture of solid paraffin hydrocarbons, having the general formula  $C_nH_{2n+2}$ .

*Properties:* White, translucent, waxy solid. Sp. gr. 0.88–0.91. Soft and hard brands are available with M. P. range from 42–60°. The M. P. is indicated for specific uses. Burns with a luminous flame.

*Uses:* In smoke boxes for TNT shells.

See Phosphorus Red.

As component of pyrotechnic compositions. In chlorate explosives.

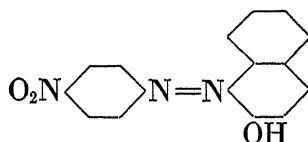
See Cheddite.

As incendiary agent in artillery shells, trench-mortar and drop bombs.

See Thermite.

## PARANITRANILINE RED (PARATONER) (PARA RED)

*Composition:*  $O_2NC_6H_4N_2C_{10}H_6OH$



*Properties:* Red powder.

*Uses:* To produce red-colored smoke for military signaling from shells, rockets, or pots.

## PELLET POWDER

*Composition:* Approximately the same in composition as Blasting Powder B, modified slightly by the addition of various ingredients to control the physical and explosive properties of the respective grades.

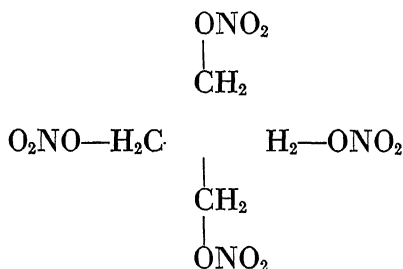
*Properties:* Pressed cylindrical pellets of approximately two-inch length, and varying in diameter from  $1\frac{1}{8}$  to  $2\frac{1}{2}$  inches, with perforation  $\frac{3}{8}$  inch in diameter. Two, three, or four of these pellets are wrapped in paraffined paper to form a standard-size cartridge 4, 6, or 8 inches in length. The wrapper provides protection for the powder from open flames. Pellet powders are safer to handle and more convenient to load than granular powders.

*Uses:* Different grades for various types of blasting, particularly in mining coal where permissible explosives are not needed. Can be used in relatively wet work. See Blasting Powder B.

# PENTAERYTHRITOL TETRANITRATE (PENTHRITE) (TETRA-NITROPENTAERYTHRITOL) (PENTAERYTHRITE TETRANITRATE)

*Symbol:* PETN

*Composition:*  $C(CH_2ONO_2)_4$



*Properties:* Fine granular powder, white or of a light-buff color. M. P.  $141^\circ$ . Quite sensitive to blows, is more readily detonated than tetryl. Detonation rate ( $d = 1.63$ ) 8000–8300 m/sec. One of the most powerful modern high explosives.<sup>30</sup>

*Uses:* In detonating and priming compositions, as base charge in antiaircraft shells, and in mixture with TNT

(30 per cent TNT, 70 per cent PETN) as H. E. charge for sea mines, drop bombs, and torpedoes in World War II.

See Pentritol.

As charge for detonating tubes.

See Primacord-Bickford.

It is one of the most effective high explosives for demolition purposes. It is used in blasting caps in combination with diazodinitrophenol, P<sup>13</sup>; with lead azide, P<sup>32</sup>. As component of pulverulent dynamite, P<sup>22</sup>.

## PENTANITROCELLULOSE

*Composition:*  $C_{12}H_{15}O_5(NO_3)_5$

Based on cellulose unit  $C_{12}H_{20}O_{10}$ .

*Properties:* 12.76 per cent nitrogen. Soluble in 2:1 ether-alcohol mixture.

*Uses:* See Pyrocotton, Dekanitrocellulose.

## PENTHRINITE (PENTRINIT)

*Composition:* A mixture of Penthrite and nitroglycerine (20–30 per cent).

*Properties:* This is one of the most, if not the most powerful explosive. It is claimed to be more sensitive than picric acid and therefore not suitable as a military explosive in shells.<sup>28</sup>

Penthrinite containing about 10 per cent Hexogen is another extremely powerful explosive and is called Hexonit.<sup>27</sup>

## PENTHRITE

See Pentaerythritol Tetranitrate.

## PENTRINIT

See Penthrinite.



**PENTRITOL**

*Composition:* Mixture of about equal parts of Penthrite and trinitrotoluene, P<sup>41</sup>.

*Properties:* One of the most powerful high-explosive mixtures.

*Uses:* As bursting charge for shells, bombs, sea mines, and torpedoes.<sup>13</sup>

See Pentaerythritol Tetranitrate.

**PENTRYL**

Commercial name for Trinitrophenylnitramine-ethyl-nitrate (See).

**PERCHLOROMETHYL FORMATE**

Chemical name for Diphosgene (See).

**PERCORONITE**

A type of German blasting explosive based on perchlorates and used in ore mines and stone quarries.

*Composition:* Example:

	PER CENT
Potassium perchlorate . . .	65
Aromatic nitro compounds . . .	25
Nitroglycerine . . . . .	5
Vegetable meal . . . . .	5

See Chlorate Explosives.

**PERMIGEL**

A brand of gelatinous permissible explosives manufactured by American Cyanamide and Chemical Corporation, New York, N. Y.

See Permissible Explosives.

## PERMISSIBLE DYNAMITES

*Composition:* One of the earlier types of permissible explosives, now largely obsolete. Dynamites containing certain amounts of salts with water of crystallization or salts which give off a large amount of gas on explosion, such as bicarbonates and oxalates, added for the purpose of cooling the explosion gases.

For additional information on composition, properties, and uses, see Ajax Powder, Hydrated Explosives, Giant Low-Flame Powder, Grisoutite.

## PERMISSIBLE EXPLOSIVES

*British:* Permitted Explosives

Permissible explosives are explosives which have been tested and approved by the U. S. Bureau of Mines and passed as safe for blasting in gaseous and dusty mines. Their use is subject to certain specific conditions.

*Composition:* Practically all permissible explosives contain ammonium nitrate, sensitized with suitable amounts of either nitroglycerine or gelatinized nitroglycerine, so that they can be detonated with a No. 6 electric detonator. They usually contain 10–15 per cent nitroglycerine or gelatinized nitroglycerine, with up to 10 per cent carbonaceous absorbing material, 50–80 per cent ammonium nitrate, and a small amount of cooling salts, such as sodium nitrate or sodium chloride, to aid in flame suppression. In some of the permissible explosives the ammonium nitrate is sensitized with nitrostarch or TNT instead of nitroglycerine.

In some of the low-density permissibles part of the wood meal is being replaced by low-density combustible materials such as bagasse pith, balsa meal, cornstalk pith,<sup>23</sup> P<sup>24</sup>.

*Properties:* Permissible explosives are either nongelatinous or gelatinous; the latter have a more shattering effect and are more water-resistant. Permissible explosives are characterized by having short flames of short duration and comparatively low temperature. Their rate of detonation is on the average about 3000 m/sec. "Low-Velocity" grades, for production of lump coal, have detonation rates of 1500–2100 m/sec.; "High-Velocity" grades, for production of fine coal, have detonation rates from 2200–4100 m/sec. The detonation temperature of permissibles is reduced by a proper choice of ingredients. Secondary flames (due to explosion gases which are combustible, such as CO) are repressed by the addition of alkaline salts.

*Uses:* As blasting explosives in "gassy" or "dusty" coal mines which have inflammable atmosphere of gas-air or coal dust-air mixtures. The nongelatinous grades are largely used for blasting coal, and the gelatinous grades for blasting rock in coal mines.

BRANDS OF EXPLOSIVES ON PERMISSIBLE LIST AS OF  
JUNE 30, 1941

From "Bureau of Mines Report of Investigation 3583."

NONGELATINOUS PERMISSIBLES	GELATINOUS PERMISSIBLES	MANUFACTURER
American Burton A Genite A	Permigel	American Cyanamide and Chemical Corp., N. Y.
Anthracite Independent	Independent-Gel	Independent Explosive Co. of Pennsylvania, Pittsburgh, Pa.
Apache Coal Powder		Apache Powder Co., Benson, Ariz.
Apcol Coalite	Gel-Coalite	Atlas Powder Co., Wilmington, Del.

Austin Red Diamond	Austin Red-D-Gel	Austin Powder Co., Cleveland, O.
Big Coal D	Liberty-Gel	Liberty Powder Co., Pittsburgh, Pa.
Big Red		Equitable Powder Manufacturing Co. and Egyptian Powder Co., East Alton, Ill.
Bituminite Collier	Hercogel	Hercules Powder Co., Wilmington, Del.
Hercoial		
Red H		
Black Diamond	Black Diamond Nu-Gel	Illinois Powder Manufacturing Co., St. Louis, Mo.
Columbia	Columbia-Gel	Columbia Powder Co., Tacoma, Wash.
Duobel	Gelobel	E. I. du Pont de Nemours & Co., Wilmington, Del.
Monobel		
King		King Powder Co., Cincinnati, O.
King Special		
Red Crown		
Trojan Coal Powder		Trojan Powder Co., Allentown, Pa.
National	Napcogel	National Powder Co., Eldred, Pa.
U. S.	U. S. Nu-Gel	United States Powder Co., Terre Haute, Ind.
U. S. Special		
Wesco Coal Powder		West Coast Powder Co., Everett, Wash.

## PERMITE

See Belgian Permite.

## PERMITTED EXPLOSIVES

British term for Permissible Explosives (See).

## PERSTOFF

German term for Diphosgene (See).

**PERTITE**

Italian term for Trinitrophenol (See).

**PETN**

Symbol for Pentaerythritol Tetranitrate (See).

**PETROLATUM**

See Mineral Jelly.

**PETROLEUM JELLY**

See Mineral Jelly.

**PHENACYL CHLORIDE**

Synonym for Chloracetophenone (See).

**PHENATE HEXAMINE (P. H.)**

*Symbol:* PH

*Composition:* A mixture of caustic soda, phenol, glycerine, and urotropine (hexamethylene tetramine) in water solution.

*Properties:* Readily neutralizes phosgene.

*Uses:* Was used in World War I in the so-called P. H. helmets as a protection against phosgene gas.

**PHENOL (CARBOLIC ACID)**

*Composition:*  $C_6H_5OH$

OH

*Properties:* White crystalline mass with characteristic odor. Corrosive and toxic. Sp. gr. 1.07 at 25°. M. P. 42°. B. P. 182°.

*Uses:* See Phenate Hexamine.

**PHENYLARSINE DICHLORIDE**

Synonym for Phenyldichlorarsine (See).

**PHENYLCHLOROMETHYL KETONE**

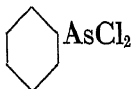
Synonym for Chloracetophenone (See).

**PHENYLDICHLORARSINE (PHENYLARSINE DICHLORIDE)**

German: Blue Cross, when used as solvent for diphenylarsine cyanide.

French: Sternite, when in mixture with 40 per cent diphenylchlorarsine.

*Composition:*  $C_6H_5AsCl_2$



*Properties:* Somewhat viscous liquid. Sp. gr. 1.65 at 20°. M. P. -20°. B. P. 255°. Vapor 7.75 times heavier than air. Decomposed by water. More toxic than phosgene.

*Uses:* Was first used by the Germans (September, 1917), and was the first toxic lung irritant used in World War I.

**PHOSGENE (CARBONYL CHLORIDE)**

Chemical Warfare Symbol: CG

British-American: CG

French: Collongite

German: D-Stoff

*Composition:*  $COCl_2$

*Properties:* Colorless gas, odor of musty hay. Vapor density 3.4. B. P. 8°. More inert and much more toxic than chlorine gas. In contact with water it decomposes into hydrochloric acid and carbon dioxide. Very powerful lung irritant; causes collapse and heart failure.

*Uses:* First used by Germans in World War I (December, 1915) in cylinders. Later used by the French (1916) as an artillery shell filler (Collingite). During the remainder of the war it was the Allies' principal war gas, used also in trench mortars, bombs, and projector drums. Also used as solvent for dispersing and spraying diphenylchlorarsine.

*Protection:* Gas mask. See also Phenate Hexamine.

*Field Neutralization:* Alkali.

## PHOSPHORIC ACID

*Composition:*  $\text{H}_3\text{PO}_4$ . The commercial grades contain various proportions of water.

*Properties:* Acid of 85–88 per cent  $\text{H}_3\text{PO}_4$  is a syrupy liquid of Sp. gr. 1.71.

*Uses:* Proposed as fire-retardant in liquid-oxygen explosives (See).

## PHOSPHORUS (RED)

*Symbol:* P

*Properties:* Reddish-brown powder, odorless, nonpoisonous. Sp. gr. 2.2 at 20°. Does not melt; ignites in air above 200°. Mixtures of red phosphorus and potassium chlorate explode from shock and from fire.

*Uses:* In combination with potassium chlorate for detonating compositions<sup>17</sup> and for pyrotechnic purposes (Railway fuses and torpedoes).

In combination with arsenious oxide and paraffin for smoke boxes in shells containing high explosives which produce no smoke (See Amatol). Production of smoke when a shell explodes helps the artilleryman to direct his firing.

**PHOSPHORUS (WHITE PHOSPHORUS) (YELLOW PHOSPHORUS)**

Chemical Warfare Symbol: WP

*Symbol:* P<sub>4</sub>

*Properties:* Pale-yellowish, translucent, crystallizable solid of waxy consistency. Sp. gr. 1.82 at 20°. M. P. 44.1°. B. P. 280°. Spontaneously inflammable in air at normal temperature; gives off dense white smoke, consisting of phosphorus pentoxide and phosphoric acid. The former has a very high obscuring power. White phosphorus has the greatest total obscuring power (T. O. P.) of all smoke agents.

*Uses:* Powerful incendiary; burning pieces adhere to skin and clothes and have a limited casualty effect. Was largely used by Allies in World War I for screening smokes in hand grenades and mortars. It is now also extensively used for incendiary purposes, in shells, bombs, and incendiary leaves, P<sup>5</sup>.

**PICRAMIDE**

Synonym for Trinitroaniline (See).

**PICRIC ACID**

Synonym for Trinitrophenol (See).

**PICRYL SULFIDE**

Synonym for Hexanitrodiphenyl Sulfide (See).

**PITCH**

*Composition:* A mixture of bituminous or resinous substances of various origins.

*Properties:* Dark-colored, thick, tenacious, fusible, more or less solid material, having characteristic "tarry" odor.



*Uses:* In torches and other smoke-producing devices. See Sulfur.

## POTASSIUM CHLORATE

*Composition:*  $\text{KClO}_3$

*Properties:* Colorless crystals or white granules. Sp. gr. 2.34. M. P.  $357^\circ$ . Decomposes at  $400^\circ$ , giving off oxygen. Soluble in hot water. Releases oxygen readily on heating with oxygen acceptors. Explodes on friction when mixed with sulfur and other combustible substances.<sup>14</sup>

*Uses:* As oxidizing agent in primer caps in combination with mercury fulminate and with red phosphorus, antimony sulfide, and other combustible substances,<sup>17</sup>  $\text{P}^{36}$ . In pyrotechnic mixtures as component of airplane flares, stars for aerial bombs and for signaling, maroons, white and colored smokes. As component of Permissibles. In incendiary projectiles,  $\text{P}^5$ .

See Antimony Sulfide, Cheddite, Phosphorus (Red), Chlorate Explosives.

## POTASSIUM NITRATE

*Composition:*  $\text{KNO}_3$

*Properties:* Colorless crystals or white powder. Sp. gr. 2.11 at  $10^\circ$ . M. P.  $337^\circ$ . Decomposes at about  $400^\circ$  with deflagration. Very soluble in hot water. Oxygen carrier.

*Uses:* Class A, Refined Potassium Nitrate, is intended for use in the manufacture of black powder and may also serve as constituent of compound propellants. Class B, Potassium Nitrate, is intended for use as an

ingredient of pyrotechnic compositions, for colored lights, rockets, and smokes.

See Double-Base Powders, E. C. Powder.

## POTASSIUM PERCHLORATE

*Composition:*  $\text{KClO}_4$

*Properties:* Colorless crystals or white crystalline powder. Sp. gr. 2.524 at 11°. Decomposes at 400°. Also decomposed by concussion, organic matter, and oxidizable substance.<sup>14</sup> Less reactive than potassium chlorate, therefore replacing the latter in various of its uses.

*Uses:* In primer compositions and in chlorate explosives. Also used to supply oxygen in aluminum and magnesium flares, smokes, stars, railway torpedoes. In combination with sulfur or antimony sulfide to produce a loud report (Maroons). As component of Permissibles, P<sup>11</sup>.

See Chlorate Explosives, Aluminum and Magnesium Flares.

## POTASSIUM PERMANGANATE

*Composition:*  $\text{KMnO}_4$

*Properties:* Dark-purple crystals with blue metallic sheen. Sp. gr. 2.70. Decomposes at 240°. Strong oxidizing agent.

*Uses:* In gas-mask canisters for destruction of toxic gases. As detonator ingredient, P<sup>31</sup>.

## POTASSIUM SULFATE

*Composition:*  $\text{K}_2\text{SO}_4$

*Properties:* Colorless or white crystals, granules, or powder. M. P. 1072°. Sp. gr. 2.66.

*Uses:* A primer composition material.

**POUDRE B**

*Composition:* A French rifle powder composed of:

	PER CENT
Guncotton . . . . .	68
Collodion cotton . . . . .	29
Vaseline . . . . .	2
Volatiles . . . . .	1

**POUDRE B. N.**

*Composition:* A French rifle powder composed of about:

	PER CENT
Guncotton . . . . .	41
Collodion cotton . . . . .	28
Barium nitrate . . . . .	19
Potassium nitrate . . . . .	8
Soda ash . . . . .	2
Volatiles . . . . .	2

**PRECIPITATED CHALK**

See Calcium Carbonate.

**PRIMACORD-BICKFORD**

*Composition:* A detonating tube (cordeau) made of waterproof textile, containing PETN as core.

*Properties:* Detonates with a velocity of about 6200 m/sec. compared with a velocity of about 5200 m/sec. for the TNT Cordeau Bickford.

*Uses:* Fired by blasting caps and used for firing blasting cartridges and charges.

See Pentaerythritol Tetranitrate, Cordeau Bickford, Bickford Fuse.

**PRIMARY EXPLOSIVES <sup>11</sup>**

A group of sensitive explosives or mixtures used in primers, detonators, and caps to initiate the explosion

of blasting, propellant, and bursting explosives at the desired moment. In order to be suitable for this purpose, they must be sensitive to shock and friction, but not too sensitive. Only a few explosives come within the required range of sensitivity. Mercury fulminate alone or in combination with potassium chlorate has been the universal initiator for many years. More recently some other initiators have been developed.

*Composition:* See Mercury Fulminate, Lead Azide, Mercury Azide, Lead Styphnate, Nitrosoguanidine, Potassium Chlorate, Hexanitromannite, Tetryl, Gun-cotton.

*Properties:* They are high explosives and are characterized by relatively great sensitivity to heat or shock. They detonate when subjected to heat or shock and are set off by the "spit" of a black-powder fuse, by the heat of an electrically heated wire, by percussion (firing pin), or by friction. Their detonation produces flame and shock, which are used to initiate the deflagration of powder or the detonation of high explosives.<sup>25</sup>

*Uses:* In priming compositions: for igniting charges of smokeless powder (small arms); for igniting the black powder in primers of artillery ammunition, and for igniting the black-powder igniters in separate-loading ammunition.

In initiating compositions: for initiating by pressure wave the detonation of high explosives in blasting cartridges, shells, bombs, mines, and torpedoes.

PS

Chemical Warfare symbol for Chlorpicrin (See).

## PYROCOTTON ("PYRO")

*Composition:* A cellulose nitrate having essentially the composition of Decanitrocellulose  $C_{24}H_{30}O_{10}(NO_3)_{10}$ .

*Properties:* White, pulped fibers. 12.6 per cent nitrogen. Soluble in ether-alcohol (2 : 1) and in acetone. Less corrosive on bore of gun than guncotton. For conversion to smokeless powder it is colloided with volatile solvents with or without addition of some non-volatile solvents.

*Uses:* In gelatinized form as the basis of all propellants; either alone, particularly for cannon powder, or in mixture with guncotton in the smaller-caliber guns (See Smokeless Powder), or in mixture with nitroglycerine in double-base powders (See).

## PYROLUSITE

*Composition:* A mineral containing 80–85 per cent manganese dioxide ( $\text{MnO}_2$ ).

*Properties:* Steel-gray in lumps, black when powdered. Sp. gr. about 4.8. Strong oxidizing agent; evolves oxygen when ignited, therefore should not be heated or rubbed with organic matter or oxidizable materials.

*Uses:* In scratch mixtures and other pyrotechnic compositions.

See Manganese Dioxide.

## PYRONITE

Commercial name for Trinitrophenylmethylnitramine (See).

## PYROXYLIN

General term for the lower nitrates of cotton, containing 11–12.6 per cent nitrogen, including collodion cotton (11–12 per cent nitrogen) and pyrocotton (12.6 per cent nitrogen).

See Nitrocellulose, Pyrocotton, Collodion Cotton.

**RACK-a-ROCK (RACKRACK EXPLOSIVE)**

*Composition:* A combination of nitrobenzene and potassium chlorate in proportion of about 1 : 4.

*Properties:* Efficient explosive, particularly under water.

*Uses:* Was used for blasting the Hellgate Rocks at the entrance to New York Harbor.

**RED CHARCOAL**

*Composition:* Incompletely carbonized wood.

*Uses:* Sporting powders.

See Charcoal.

**RED CROWN**

A brand of nongelatinous permissible explosives manufactured by King Powder Co., Cincinnati, O.

See Permissible Explosives.

**RED H**

A brand of nongelatinous permissible explosives manufactured by Hercules Powder Co., Wilmington, Del.

See Permissible Explosives.

**ROBURITE**

*Composition:* A type of smokeless and flameless safety mining explosive containing about 86 per cent ammonium nitrate in combination with either dinitrobenzene or dinitrochlorobenzene. The disadvantage of this type of explosive is low sensitiveness and defective propagation. Later improved similar explosives contain small amounts of nitroglycerine.

**ROSIN (COLOPHONY) (GUM ROSIN)**

*Composition:* Consists largely of abietic acid  $C_{19}H_{29}COOH$  and its anhydride.

*Properties:* Yellow or amber amorphous lumps of brittle fracture. Sp. gr. 1.08. Melts readily on heating to 100–140°. Gives off inflammable vapors when heated.

*Uses:* Imbedding material for steel balls in shrapnel shells. As binder in pyrotechnic compositions to prevent segregation.<sup>22</sup>

See Sulfur.

## RYE MEAL

A vegetable meal used as an absorbent for nitroglycerine in the manufacture of dynamites (See).

## SABULITE

See Belgian Permite.

## SAFETY EXPLOSIVES

*Composition:* A type of explosive, originally containing ammonium nitrate and charcoal, introduced for the purpose of preventing explosions in coal mines. Hundreds of Safety Explosives of various combinations have been on the market, containing a great number of different products, including: ammonium nitrate, nitroglycerine, gelatinized nitroglycerine, mineral salts, aromatic nitro compounds, wood meal, wood pulp, etc.

*Properties:* Flame of explosion relatively short and of short duration; explosion temperature relatively low and enduring only a short time.

*Uses:* As blasting explosives for mining. For blasting in gaseous and dusty coal mines only approved Safety Explosives may be used; they are called Permitted Explosives (England) or Permissible Explosives (U. S.). Term *Safety Explosives* now obsolete.  
See Permissible Explosives.

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**SAL AMMONIAC**

Technical term for Ammonium Chloride (See).

**SAL SODA**

See Washing Soda.

**SCHNEIDERITE**

*Composition:* A combination of 1 part dinitronaphthalene and 7 parts ammonium nitrate.

*Uses:* As shell-filler in France and Italy during World War I.

**SCREENING SMOKES**

Chemical agents which produce an obscuring smoke. See Titanium Tetrachloride, Silicon Tetrachloride, Chlorsulfonic Acid-Sulfur Trioxide Solution.

**SEMIGELATINE DYNAMITE**

*Composition:* The principal explosive ingredient is ammonium nitrate sensitized by a small quantity of a gelatinized explosive oil. This dynamite contains about 0.3 per cent collodion cotton.

*Properties:* More water-resistant than ammonia dynamites. Commercial strength 45–60 per cent.

*Uses:* For blasting rocks and ores of moderate hardness, such as limestone and gypsum.

**SHELLAC**

*Composition:* A complex mixture consisting mostly of resins.

*Properties:* Yellowish-brown leaflets. Sp. gr. 1.08–1.13. Soluble in alcohol and many other organic solvents.



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*Uses:* The solutions are used as binder, for coating and cementing in munitions and pyrotechnic devices.  
See Aluminum Flares.

## SHIMOSE

Japanese name for Trinitrophenol (Picric Acid). Was used in the Russo-Japanese War.

## SILICON TETRACHLORIDE

*Composition:*  $\text{SiCl}_4$

*Properties:* Colorless, fuming liquid. Suffocating odor. Sp. gr. 1.5. M. P.  $-70^\circ$ . B. P.  $57.6^\circ$ . Decomposes with the moisture of the air, forming a dispersion of silicic acid and hydrogen chloride.

*Uses:* For producing screening smokes (British attack on Zeebrugge). In combination with ammonia vapor it forms smokes which resemble natural fog and which are effective for camouflaging troop or ship movements. The smoke is generated from a smoke funnel. One cylinder contains liquid ammonia; the other cylinder is charged with silicon tetrachloride containing about 10 per cent carbon dioxide under a maximum pressure of 550 lb/sq. in. at  $55^\circ$ .

## SILVER ACETYLIDE

*Composition:*  $\text{Ag}_2\text{C}_2$

*Properties:* One of the very few explosives containing neither nitrogen nor oxygen, and producing no gas on explosion. The explosion is a heat effect only.

*Uses:* For detonating compositions. In combination with lead azide for detonating rivets, for the purpose of reducing the flash point of the lead azide,  $\text{P}^7$ .

**SILVER PERMANGANATE**

*Composition:*  $\text{AgMnO}_4$

*Properties:* Violet, crystalline powder. Decomposes in light.

*Uses:* In primer compositions.

**SINGLE-BASE POWDER**

*Composition:* A straight nitrocellulose powder, with nitrocellulose as the only explosive constituent.

*Properties:* Degree of nitration as measured by per cent nitrogen determines energy and gas liberated. Pyrocotton (12.6 per cent nitrogen) is the lowest in nitrogen ordinarily used; guncotton (13.0–13.5 per cent nitrogen) is the highest. Most powders are blends of these two.

*Uses:* Standard service powder of U. S. Army and U. S. Navy.

See Smokeless Powder, Cellulose Nitrate, I. M. R. Powder.

**SMOKE**

See:

Auramine

Chlorsulfonic Acid-Sulfur Trioxide Solution

Chrysoidine

Indigo

Paranitraniline Red

Phosphorus (Red) (White)

Potassium Chlorate

Potassium Perchlorate

Silicon Tetrachloride

Strontium Nitrate

Sulfur

Sulfur Trioxide

Tin Tetrachloride

Zinc Dust

## SMOKELESS POWDER

The universal propellant, with nitrocellulose as chief explosive ingredient. Nitrocellulose in its natural fibrous form, either loose or compressed, has too high a rate of combustion to be suitable as a propellant. Gun-cotton, the nitrocellulose of highest nitrogen content, is a high explosive. In 1886 Vieille introduced nitrocellulose smokeless powder. He treated nitrocellulose with ether and alcohol, which acted as colloidizing agent, forming a gelatinous mass. When rolled into sheets, cut into small squares, and then dried, the product had the progressive burning characteristics required for a propellant. Shortly afterwards, Nobel gelatinized the nitrocellulose with nitroglycerine and introduced the first double-base smokeless powder. The U. S. Army and U. S. Navy have adopted single-base, or straight nitrocellulose, powder for standard service ammunition. For special types of ammunition, however, a double-base powder is being used. More recent developments have led to the development of NH (non-hygroscopic) powders and FNH (flashless non-hygroscopic) powders.

*Composition:* Single-base powder is composed of gelatinized nitrocellulose. It is not a single definite compound but a mixture of products nitrated to varying degrees. Small amounts of modifying agents are added for specific purposes. Nitrocellulose decomposes very slowly in long-continued storage, causing deterioration of the powder. About 1 per cent of diphenylamine is incorporated in the powder as a stabilizer to retard the rate of decomposition and prolong the life of the powder. A coating of graphite is applied to rifle powder for the purpose of facilitating the pouring of the grains in loading operations and for preventing the collection of electrostatic charges. Small amounts of

other substances are incorporated in the powder as deterrents to regulate the burning of the powder; as either cooling or oxidizing agents to reduce smoke and muzzle flash; and as plastic, or moisture-resistant, materials to reduce hygroscopicity of the powder.

*Properties:* Smokeless powder is not used in powder form. It is grained into solid cylindrical particles (cords, Cordite) or into cylindrical perforated particles (U. S. Service Powder). Rifle powder has one perforation; all other grains have seven perforations. The grains are produced in many sizes for use in guns of different caliber. The nitrocellulose used is pyrocotton containing 12.6 per cent nitrogen, which produces a superior colloid with a mixture of ether and alcohol. Guncotton of 13 per cent nitrogen and over is only partially soluble but can be colloidized and grained together with suitable proportions of pyrocotton. Fast and slow powders are produced for various purposes. They differ in composition and physical size and shape of the grains. The powders burn under confinement with progressive rapidity (deflagration), evolving about 1000 calories of heat and about 900 cc. of gas per gram.

*Uses:* Has universally replaced black powder as propellant for practically all types of weapons.

See Propellants, Single-Base Powders, Double-Base Powders, I. M. R. Powder, Sporting Powder, Nitrocellulose, Pyrocotton, Guncotton, Ball Powder, P<sup>1,12,27</sup>. See also P<sup>16,17,18,19,20,21,26</sup>.

## SNEEZE GAS

See Sternutators.

## SO

Chemical Warfare symbol for Solid Oil (See).

## SODA LIME

*Composition:* A mixture of caustic soda ( $\text{NaOH}$ ) and hydrated lime ( $\text{Ca}(\text{OH})_2$ ).

*Properties:* White or gray granules or powder. When used for gas masks additional agents are used: such as cement, to provide sufficient hardness of the granules to withstand service conditions; kieselguhr, to increase porosity; and sodium or potassium permanganate, for removal of oxidizable gases.<sup>9</sup>

*Uses:* In gas masks for the absorption of volatile acid gases.

## SODATOL

*Composition:* Mixture of TNT and sodium nitrate.

*Properties:* Yellow crystalline mass.

*Uses:* See Trinitrotoluene.

## SODIUM BICARBONATE

*Composition:*  $\text{NaHCO}_3$

*Properties:* White crystals, powder, or granules. Sp. gr. 2.2. Begins to lose carbon dioxide at about  $50^\circ$ .

*Uses:* Component of cooling-sheath compositions for blasting explosives, P<sup>28,29</sup>.

## SODIUM CHLORATE

*Composition:*  $\text{NaClO}_3$

*Properties:* Colorless crystals. Sp. gr. 2.5. M. P.  $250^\circ$ . Begins to liberate oxygen at about  $300^\circ$ . Its hygroscopicity is a disadvantage; can be corrected with suitable coating.<sup>24</sup>

*Uses:* As oxidizer in explosive and pyrotechnic compositions.

## SODIUM CHLORIDE (COMMON SALT)

*Composition:* NaCl

*Properties:* Colorless crystals or white crystalline powder. Sp. gr. 2.16. M. P. 804°. B. P. 1490°.

*Uses:* In some ammonium nitrate permissible explosives, added for the purpose of reducing brisance and heat of explosion in quantities of 8–27 per cent depending on the percentage of ammonium nitrate in the mixture. In chlorate explosives, P<sup>11</sup>.

See Abbcite, Wetter-Astralit.

## SODIUM HYPOSULFITE

See Sodium Thiosulfate.

## SODIUM NITRATE (CHILE SALTPETER)

*Composition:* NaNO<sub>3</sub>

*Properties:* Colorless crystals, white granules or powder. Sp. gr. 2.26. M. P. 308°. Decomposes at about 380°. Deliquescent in moist air.

*Uses:* As component of powders.

See Black Powder (With Sodium Nitrate), Blasting Powder B, Pellet Powder.

As component of permissible explosives and pyrotechnic devices. Used also in ammonia dynamites (See).

## SODIUM PERMANGANATE

*Composition:* NaMnO<sub>4</sub> · 3H<sub>2</sub>O

*Properties:* Purple or reddish-black crystals or powder. Oxidizing agent.

*Uses:* In gas masks for removing oxidizable poison gases.

See Soda Lime.

**SODIUM PEROXIDE (SODIUM DIOXIDE) (SODIUM SUPEROXIDE)**

*Composition:*  $\text{Na}_2\text{O}_2$

*Properties:* Yellowish-white granular powder. Sp. gr. 2.8. Decomposes on heating, soluble in water with decomposition. Attracts moisture from the air. Reacts readily with combustible materials with evolution of heat. The reaction may result in ignition or explosion.

*Uses:* In pyrotechnics.

See Thermite.

As component of incendiary mixtures.<sup>22</sup>

**SODIUM SULFITE**

*Composition:*  $\text{Na}_2\text{SO}_3$

*Properties:* White powder. Sp. gr. 2.63. M. P.  $150^\circ$ . Soluble in water.

*Uses:* For field neutralization of Chlorpicrin.

See Chlorpicrin.

**SODIUM THIOSULFATE (SODIUM HYPOSULFITE) ("HYPO")**

*Composition:*  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

*Properties:* Colorless crystals. Sp. gr. 1.73. Melts between  $32^\circ$  and  $48^\circ$ . Loses its water of crystallization at  $100^\circ$  and decomposes at  $220^\circ$ . Soluble in water.

*Uses:* Pads dipped into a solution of "hypo," washing soda, and glycerine were used in World War I as a protection against chlorine gas.

**SOFT PARAFFIN**

See Mineral Jelly.

**SOLID OIL**

Chemical Warfare symbol: SO

*Composition:* Mixture of liquid paraffin hydrocarbons (fuel oil) with some colloidal substances.

*Properties:* A small percentage of the oil has a relatively low fire point and burns readily. The heat generated melts and ignites the bulk of the product which has a moderately high fire point.

*Uses:* As incendiary agent in drop bombs and artillery shells. Also suitable in other incendiary devices, such as Livens projector drums and trench-mortar bombs.

## "SOUP"

Safe-blowers' term for Nitroglycerine (See).

## SPORTING POWDERS

*Composition:* Similar to that of double-base powders; contain nitroglycerine and/or nitrates in combination with the nitrocellulose base.

*Properties:* More readily ignitable and having a higher rate of burning than straight nitrocellulose powder.

*Uses:* In sporting ammunition.

## SPRENGEL EXPLOSIVES

*Composition:* Mixtures of nitrobenzene and red fuming nitric acid; for example, in proportion 28:72.

*Properties:* Powerful and cheap explosives, but on account of practical disadvantages, their use was discontinued.

*Uses:* The components had to be mixed in glass containers shortly before the explosive was required for use.

## SPRENGMUNITION-02

German military term for Trinitrotoluene (See).

## STANNIC CHLORIDE

See Tin Tetrachloride.



**STANNIC OXIDE**

See Tin Dioxide.

**STARCH NITRATE**

Chemical name for what is commonly called Nitro-starch (See).

**STERNITE**

See Phenylchlorarsine.

**STERNUTATORS (SNEEZE GASES) <sup>16</sup>**

Harassing agents causing coughing, sneezing, nausea, and temporary physical disability.

See Diphenylchlorarsine, Diphenylaminearsine Chloride, Diphenylcyanoarsine.

**STRAIGHT DYNAMITE**

*Composition:* Contains 15–60 per cent nitroglycerine, absorbed in wood meal or other absorbent materials. It is the standard dynamite in comparison with which all other dynamites are rated for strength on a weight for weight basis.

*Properties:* More sensitive than other types of dynamite, and the sensitiveness increases with the strength. Extremely fast and shattering in action. Most water-resistant of any of the dynamites.

*Uses:* A most efficient explosive for submarine blasting, ditch blasting by propagation, scrapping boilers, ships, etc., where quickness is the essential quality. As primer for gelatines in deep-well blasting. Being replaced in large measure by the cheaper ammonia dynamites.

See Dynamite, Nitroglycerine.

**STRONTIUM DIOXIDE**

See Strontium Peroxide.

**STRONTIUM NITRATE**

*Composition:*  $\text{Sr}(\text{NO}_3)_2$

*Properties:* White granules or powder. Sp. gr. 2.98. M. P.  $570^\circ$ . Releases oxygen when heated with combustible materials and imparts a red color to the flame. Gives a brilliant, almost white light in mixture with the proper amount of barium nitrate and oxidizable materials, P<sup>2</sup>.

*Uses:* For tracer powder and red-colored flares. In combination with barium nitrate it is used in aviation for signaling and for illuminating landing fields and military objectives. In marine signals, matches, and railroad flares.

**STRONTIUM OXALATE**

*Composition:*  $\text{SrC}_2\text{O}_4 \cdot \text{H}_2\text{O}$

*Properties:* White crystalline powder. Decomposes on heating. Burns with red light.

Grade A: 99 per cent through 140 U. S. standard sieve.

Grade B: 99 per cent through 66-mesh sieve.

*Uses:* In pyrotechnic compositions, such as colored stars.

**STRONTIUM PEROXIDE (STRONTIUM DIOXIDE)**

*Composition:*  $\text{SrO}_2$

*Properties:* Grayish-white powder. Commercial product contains about 85 per cent  $\text{SrO}_2$ , equivalent to 11.5 per cent available oxygen. Decomposes on heating and gradually on exposure to air.

*Uses:* As component of tracer powder and other pyrotechnics.

**SULFUR (BRIMSTONE)**

*Symbol:* S

*Properties:* Yellow powder. Sp. gr. 2.05. M. P. about 120°. Ignites at about 250°. B. P. 444.6°. Ignites readily and therefore facilitates ignition of black powder and other ignitable mixtures. Sulfur decreases the temperature of detonation of TNB, TNT, and picric acid; to a lesser degree sulfur lowers the temperature of detonation of Tetryl and Pentrite. Sulfur raises the temperature of detonation of Hexogen and increases the sensitivity of Tetryl to shock (maximum at 10 per cent sulfur).<sup>3</sup>

*Uses:* Component of black powder. In aluminum and magnesium flares. In torches for black smoke in combination with potassium nitrate and rosin or pitch. In many other pyrotechnical devices. Grade A sulfur is intended for use in the manufacture of black powder. Grade B sulfur is intended for use in the manufacture of pyrotechnic compositions. Grade C sulfur is intended for use as an ingredient of priming compositions. Sulfur is also used as an ingredient of some dynamite. It is used, too, as an accelerant in ignition compositions for blasting-caps, P<sup>36</sup>.  
See Ammonia Dynamite.

**SULFUR DIOXIDE**

*Composition:* SO<sub>2</sub>

*Properties:* Colorless, noninflammable gas, of suffocating odor. Vapor density 2.3. M. P. -76.1°. B. P. -10°.

*Uses:* As fumigant.

**SULFUR TRIOXIDE**

*Composition:* SO<sub>3</sub>

*Properties:* Colorless prisms. Sp. gr. 1.92. M. P. 16.8°. B. P. 46°. It fumes on contact with the air and throws off white clouds composed of minute droplets of sulfuric acid. Soluble in concentrated sulfuric and in chlorsulfonic acid.

*Uses:* As smoke-producing material.

See Chlorsulfonic Acid-Sulfur Trioxide Solution.

## SULFUR TRIOXIDE-CHLORSULFONIC ACID

See Chlorsulfonic Acid-Sulfur Trioxide Solution.

## SUPER EXCELLITE

An English Permissible Explosive.

*Composition:*

	PER CENT
Nitroglycerine . . . .	8.5-10.5
Ammonium nitrate . . .	62.0-65.0
Common salt . . . .	18.5-20.5
Wood meal, dried at 100°	4.5- 6.5
Magnesium carbonate .	0.0- 1.5
Moisture . . . . .	0.0- 2.0

*Properties and Uses:* See Permissible Explosives.

## SUPERPALITE

See Diphosgene.

## SURPALITE

French name for Diphosgene (See).

## SYM-TRIMETHYLENE TRINITRAMINE

See Trimethylene Trinitramine.

## SYM-TRINITROBENZENE

See Trinitrobenzene.

**SYM-TRINITROPHENOL**

See Trinitrophenol.

**SYM-TRINITROTOLUENE**

Chemical name for TNT.

See Trinitrotoluene.

**SYSTEMIC POISONS**

Chemical agents which affect the heart action and nerve reflexes or interfere with the assimilation of oxygen by the body.

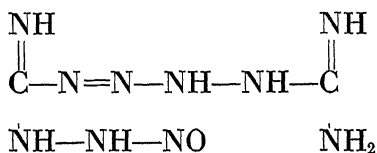
See Hydrocyanic Acid, Cyanogen Bromide, Cyanogen Chloride.

**TEAR GAS**

Common name for Lacrimators (See).

**TETRACENE (TETRAZINE)**

*Composition:* Guanylnitrosaminoguanilyltetrazene.



*Properties:* Yellow, fluffy solid. Explodes at about 160° and gives large volume of flame.<sup>35</sup>

*Uses:* In priming compositions. In explosives for detonating rivets, in combination with lead azide, for the purpose of reducing the flash point of the latter, p<sub>7,8,9,10</sub>.

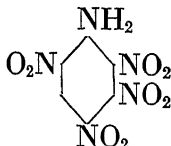
**TETRALITE**

See Trinitrophenylmethylnitramine.

## TETRANITROANILINE

*Symbol:* TNA

*Composition:*  $C_6H(NH)_2(NO_2)_4$



*Properties:* Brownish crystals. Melts with decomposition at  $210^\circ$  and deflagrates at about  $226^\circ$ . Powerful and sensitive high explosive, similar to Tetryl. Detonation rate ( $d = 1.6$ ) 7500 m/sec. On long storage stability not very satisfactory, particularly in presence of moisture, which tends to promote hydrolysis.<sup>37</sup>

*Uses:* As booster for H. E. shells. In primer and detonating compositions.

## TETRANITROCELLULOSE

*Composition:*  $C_{12}H_{16}O_6(NO_3)_4$

Based on cellulose unit  $C_{12}H_{20}O_{10}$

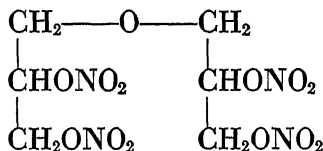
*Properties:* 11.11 per cent nitrogen.

*Uses:* See Collodion Cotton.

See Oktonitrocellulose.

## TETRANITRODIGLYCERINE

*Composition:*  $C_3H_5(ONO_2)_2OC_3H_5(ONO_2)_2$

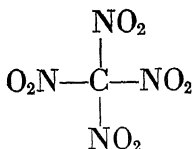


*Properties:* Thick oil. Behaves like nitroglycerine but is somewhat less sensitive.

*Uses:* As component of Low-Freezing Dynamites (See).

## TETRANITROMETHANE

*Composition:*  $C(NO_2)_4$

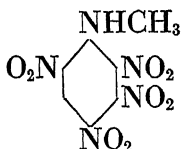


*Properties:* Colorless liquid. B. P.  $126^\circ$ . Has large excess of oxygen. Gives very powerful explosives when mixed with some other nitro high explosives which are deficient in oxygen.<sup>4,19</sup>

*Uses:* In detonating compositions. In blasting explosives, P<sup>35</sup>.

## TETRANITROMETHYLANILINE

*Composition:*  $C_6H(NHCH_3)(NO_2)_4$



Not used in the explosive industry.

Tetryl is sometimes wrongly designated as tetranitromethylaniline.

See Trinitrophenylmethylnitramine.

## TETRANITRONAPHTHALENE

*Composition:* A mixture of several isomeric tetranitronaphthalenes.

*Properties:* Satisfactory high explosive for bursting charges, about as powerful as TNT and less sensitive to impact, but higher in cost. M. P. about  $220^\circ$ .

*Uses:* Could be considered as a reserve explosive.

## TETRANITROPENTAERYTHRITOL

See Pentaerythritol Tetranitrate.

## TETRYL

Common name for Trinitrophenylmethylnitramine (See).

Standard booster explosive.

## TH

Chemical Warfare symbol for Thermit (See), when used in non-magnesium containers.

## THERMIT

Chemical Warfare symbol: TH

*Composition:* An intimate mixture of finely divided aluminum powder and iron oxide ( $\text{Fe}_2\text{O}_3$ ) or magnetic iron oxide ( $\text{Fe}_3\text{O}_4$ ).

*Properties:* When reaction is initiated by strong heat, it proceeds throughout the mixture with great evolution of heat and the formation of a white-hot mass of molten iron and slag. The initiating heat is produced by firing a charge of aluminum powder and sodium peroxide or barium peroxide by means of a fuse, P<sup>3</sup>. Binders may be used to prevent the components of the Thermit from segregating. When sulfur is used, the resulting Thermit is called Daisite.

*Uses:* Alone as incendiary agent or as primary igniting incendiary for secondary incendiary material such as heavy hydrocarbons, or for igniting the casing of incendiary bombs made of a magnesium alloy.  
See Magnesium, Solid Oil, Crude Oil.



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**TIN**

*Symbol:* Sn

*Properties:* Lustrous metal. Sp. gr. 7.31. M. P. 231.9°. B. P. 1450–1600°. Easily powdered.

*Uses:* Powdered tin is used for reducing flash of smokeless powder.

**TIN DIOXIDE (STANNIC OXIDE) (FLOWERS OF TIN)**

*Composition:*  $\text{SnO}_2$

*Properties:* White or slightly gray powder, amorphous or crystalline. Sp. gr. 6.8. M. P. 1127° for the amorphous. The crystalline product is infusible.

*Uses:* For reducing flash of smokeless powder.

**TIN TETRACHLORIDE (STANNIC CHLORIDE)**

British: KJ

French: Opacite

*Composition:*  $\text{SnCl}_4$

*Properties:* Colorless fuming liquid. Sp. gr. 2.23. M. P. — 33°. B. P. 114°. Decomposed by hot water. With steam it forms a dispersion of stannic hydroxide and hydrogen chloride.

*Uses:* Was used as smoke agent in French shells in mixture with phosgene and chlorpicrin.

**TITANIUM TETRACHLORIDE**

Chemical Warfare symbol: FM

German: F-Stoff

*Composition:*  $\text{TiCl}_4$

*Properties:* Colorless liquid. Sp. gr. 1.76 at 0°. Solidifies — 30°. B. P. 136.4°. Absorbs moisture and evolves dense fumes consisting of a dispersion of titanous acid hydrate and hydrogen chloride.

*Uses:* For producing smoke; the latter can be made more dense by combination with ammonia vapors. Employed in airplane exhaust smoke, in explosive type of munitions, or by spraying.

**TNA**

Symbol for Tetranitroaniline (See).

**TNB**

Symbol for Trinitrobenzene (See).

**TNT**

Symbol for Trinitrotoluene (See).

**TNX**

Symbol for Trinitroxylene (See).

**TOLITE**

French name for Trinitrotoluene (See).

**TONITE**

*Composition:* A blasting explosive containing dinitrobenzene, guncotton, and barium nitrate in the proportion of 13:19:68.

**"TORPEDO EXPLOSIVE NO. 1"**

Commercial term for Blasting Gelatine (See).

**TRIACETIN**

Commercial name for Glyceryl Triacetate (See).

**TRICHLOROMETHYL CHLOROFORMATE**

Chemical name for Diphosgene (See).

**TRICHLORONITROMETHANE**

Chemical name for Chlorpicrin (See).

**TRICHLORTRIVINYLSARSINE**

See Vinylchlorarsine.

**TRIDITE**

*Composition:* Mixture consisting of 80 per cent trinitrophenol and 20 per cent dinitrophenol.

*Properties:* Addition of dinitrophenol lowers the melting point of the trinitrophenol (picric acid). The mixture can be cast, and the charge is free from exudation. Detonation rate about 6300 m/sec.

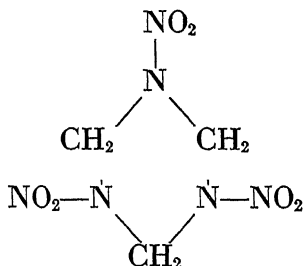
*Uses:* For bursting charges.  
See Trinitrophenol.

**TRILITE**

Commercial name for Trinitrotoluene (See).

**TRIMETHYLENE TRINITRAMINE (CYCLONITE) (CYCLO-TRIMETHYLENETRINITRAMINE) (HEXOGEN)**

*Composition:*  $(\text{CH}_2)_3\text{N}_3(\text{NO}_2)_3$



*Properties:* White crystals. M. P. 202°. One of the most powerful modern high explosives. Detonation rate ( $d = 1.60$ ) 8400 m/sec. Has greater brisance than TNT.

*Uses:* In mixture with TNT (70 per cent) as bursting charge for aerial bombs, sea mines, torpedoes in World

War II.<sup>18</sup> Disadvantage for more general application is that it requires 10 pounds of nitric acid for 1 pound of cyclonite. Like Tetryl, it can be used as a booster, being easily initiated by mercury fulminate.

### TRIMONITE

*Composition:* A mixture consisting of 90 per cent trinitrophenol (picric acid) and 10 per cent mononitronaphthalene.

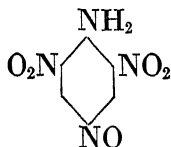
*Properties:* Addition of nitronaphthalene lowers the melting point of the picric acid and makes it safer for loading into shells by casting. The mixture becomes fluid at about 100°. Like picric acid, it forms sensitive compounds with some metals (zinc, lead).

*Uses:* Specified as a substitute or reserve explosive for bursting charges.

See Trinitrophenol.

### TRINITROANILINE (PICRAMIDE) (PICRAMITE)

*Composition:*  $C_6H_2NH_2(NO_2)_3$

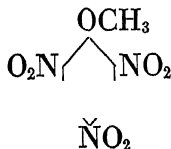


*Properties:* Orange-red crystals. M. P. 186–188°. Fairly powerful explosive.

*Uses:* Of no particular interest as an explosive.

### TRINITROANISOLE (METHYL PICRATE) (TRINITROPHENYL METHYL ETHER)

*Composition:*  $C_6H_2OCH_3(NO_2)_3$



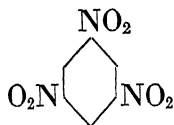
*Properties:* Yellow crystals. M. P. 67–68°. Other properties similar to those of picric acid. It has the advantage that it does not attack metals provided it is protected from moisture. The lower melting point gives a further advantage in shell-loading.

*Uses:* As booster charge. During World War I the Germans used a mixture of trinitroanisole and hexanitrodiphenyl sulfide in bombs.

## TRINITROBENZENE (TNB) (SYM-TRINITROBENZENE)

*Symbol:* TNB

*Composition:*  $C_6H_3(NO_2)_3$



*Properties:* Yellow crystals. Sp. gr. 1.69 at 20°. M. P. 121.2°. More powerful and having higher brisance than TNT, but producing smaller shell fragments. Less sensitive to impact and more toxic than TNT. Rate of detonation ( $d = 1.66$ ) 7350 m/sec., compared with 7140 m/sec. for TNT ( $d = 1.60$ ) when tested under similar conditions.

*Uses:* Not used in explosives on account of difficulties encountered in its large-scale production (low yield).

## TRINITROBENZOL

See Trinitrobenzene.

## TRINITROCELLULOSE

*Composition:*  $C_6H_7O_2(NO_3)_3$

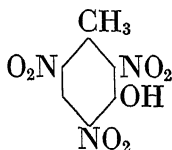
Highest degree of nitration based on cellulose unit of  $C_6H_{10}O_5$ .

*Properties:* 14.14 per cent nitrogen. So far has not been produced in stable form. The highest grade of

guncotton contains about 13.5–13.7 per cent nitrogen. See Hexanitrocellulose, Dodekanitrocellulose, Guncotton, Nitrocellulose.

### TRINITROCRESOL (CRESYLITE) (TRINITRO-*m*-CRESOL)

*Composition:*  $C_6HCH_3(OH)(NO_2)_3CH_3$



*Properties:* Yellow needles. M. P. 109°. Weaker than TNT and picric acid.

*Uses:* Was used as bursting charge in various combinations with other high explosives.

See MDPC.

The ammonium salt was used in Austria for shells of large caliber.

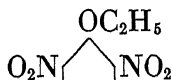
See Ecrasite.

### TRINITRO-*m*-XYLENE

See Trinitroxylylene.

### TRINITROPHENETOLE (ETHYL PICRATE) (TRINITROPHENYL ETHYL ETHER)

*Composition:*  $C_6H_2OC_2H_5(NO_2)_3$



*Properties:* Yellow crystals. M. P. 78°. Other properties and uses comparable with those of Trinitroanisole (See).

## TRINITROPHENOL (PICRIC ACID) (SYM-TRINITROPHENOL)

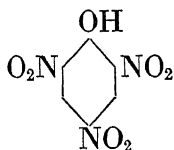
British: Lyddite

French: Melinite

Japanese: Shimose

Italian: Pertite

*Composition:*  $C_6H_2OH(NO_2)_3$



*Properties:* Pale-yellow crystals. Sp. gr. 1.76. M. P. 122–123°. Explodes above 300°. The fusion temperature is too high for safe casting; therefore other nitro explosives are added to reduce the melting point. When used alone, it is press-loaded. Detonation rate ( $d = 1.53$ ) 7000 m/sec. Corrosive to metals, forming metal picrates which are very sensitive and dangerous; therefore the cavity of the shell must be lined by tinning or with a varnish or synthetic resin surface.

*Uses:* Was one of the most important shell-fillers during World War I. Used alone or in mixture with other nitro compounds such as dinitrophenol and nitronaphthalene.

See Tridite, Trimonite, MPDC.

For loading of high-explosive shells, it has been largely replaced by TNT. However, picric acid and its compositions can still be considered a reserve explosive for this purpose. As component of priming compositions. Picric acid is manufactured in large quantities for the production of armor-piercing explosives.

See Ammonium Picrate.

## TRINITROPHENYL ETHYL ETHER

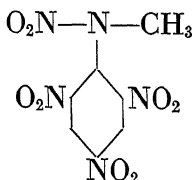
See Trinitrophenetole.

## TRINITROPHENYL METHYL ETHER

See Trinitroanisole.

## TRINITROPHENYLMETHYLNITRAMINE (TETRYL) (TETRA-LITE) (PYRONITE)

*Composition:*  $C_6H_2(NO_2)_3(NCH_3NO_2)$



Sometimes erroneously called methyltetranitroaniline or tetranitromethylaniline.

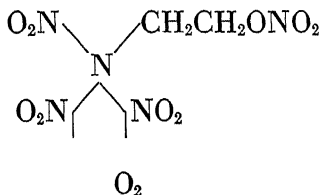
*Properties:* Yellow crystals or granules. M. P. 129–130°. 24.4 per cent nitrogen. Rate of detonation ( $d = 1.7$ ) 7200–7300 m/sec. Rather sensitive to impact. Stable, but more sensitive to shock and friction than TNT. Loaded by pressing. Can be compressed into pellets for use as booster explosive. Toxic.<sup>42</sup>

*Uses:* In reinforced detonators. Standard booster explosive for high-explosive shells. It is the base for the service Tetryl caps which are necessary for positive detonation of TNT. A mixture of fulminate of mercury and potassium chlorate is included in the cap to insure detonation of Tetryl.

See Boosters.

## TRINITROPHENYLNITRAMINE-ETHYL NITRATE (PENTRYL)

*Composition:*  $C_6H_2(NO_2)_3N(NO_2)(CH_2)_2NO_3$





*Properties:* Yellowish, nearly white crystals. M. P. 128°. Explodes when heated to 235°. Sp. gr. 1.82. Soluble in nitroglycerine. Sensitivity to impact similar to, and sensitivity to friction somewhat greater than, that of Tetryl; but the shattering power is much greater for the Pentryl. The disruptive power of Pentryl as measured in the small Trauzl block is 30 per cent greater than that of TNT, 15 per cent greater than that of Tetryl, and 27 per cent greater than that of picric acid.<sup>5</sup> Rate of detonation ( $d = 0.8$ ) 5000 m/sec.

*Uses:* Similar to Trinitrophenylmethylnitramine (See). Particularly effective as a base charge in compound detonators.

**TRINITROTOLUENE (TRILITE) (TRITOL) (TRITON) (ALPHA-TRINITROTOLUENE) (SYM-TRINITROTOLUENE) (1,2,4,6-TRINITROTOLUENE)**

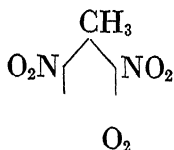
*Symbol:* TNT

British: Trotyl

French: Tolite

German: Sprengmunition-02

*Composition:*  $C_6H_2(CH_3)(NO_2)_3$



*Properties:* Yellow crystals. Sp. gr. 1.654. M. P. 80.8°.

U. S. Army grade 1, setting point 80.2°.

U. S. Army grade 2, setting point 76.0°.

Explodes at 240–280°. In small quantities it burns without danger of detonation. In large quantities, the heat generated by burning will raise the temperature

to the detonating point. The rate of detonation increases with the density. It is 6700 m/sec at  $d = 1.6$ . TNT is toxic and on prolonged exposure may cause serious injury when absorbed through the skin or by inhalation of the dust or vapor.

It forms unstable and dangerous compounds in presence of alkalis. TNT is comparatively insensitive to shock. In crystalline form it can readily be detonated with mercury fulminate; in compressed form it requires a powerful detonator. When it is used in cast form, it is necessary to interpose a booster, noncompressed TNT or Tetryl being suitable for this purpose. Compressed granular Tetryl is generally used in combination with bursting charges.

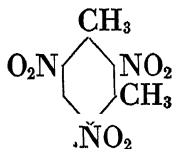
*Uses:* It is the standard high explosive as bursting charge for bombs and shells (except armor-piercing) and is used alone or in mixture with ammonium nitrate (See Amatol). TNT has replaced guncotton and picric acid in submarine mines and torpedo warheads. It is a quick-acting explosive and is suitable for all kinds of blasting and demolition work. It is also used in the manufacture of detonating fuse (cordeau), reinforced detonators, and in some grades of dynamite and safety explosives. As component of smokeless powder, <sup>18,21</sup>

See High Explosives, Boosters, Ammonite.

## TRINITROXYLENE (TRINITRO-*m*-XYLENE)<sup>13</sup>

*Symbol:* TNX

*Composition:*  $C_6H(CH_3)_2(NO_2)_3$



*Properties:* Yellow crystals. M. P. 182°. Not very powerful when used alone. Addition of TNT, picric acid, or other nitro high explosives serves the purpose of lowering the melting point as well as that of reinforcement. Mixtures of TNX and ammonium nitrate can be loaded by compression.

*Uses:* In detonating compositions and in mixture with other high explosives as bursting charge. Alone or in mixture with other trinitroxylenes in commercial dynamites. Can be considered as a reserve explosive. Was produced in this country towards the end of World War I and was to be used as a partial substitute for TNT by casting a mixture of TNX suspended in molten TNT.

## TRITOL (TRITON)

Commercial name for Trinitrotoluene (See).

## TROJAN COAL POWDER

A brand of nongelatinous permissible explosives manufactured by Trojan Powder Co., Allentown, Pa.  
See Permissible Explosives.

## TROJAN EXPLOSIVE

*Composition:*

	PER CENT
Nitrostarch . . .	23 - 27
Ammonium nitrate .	31 - 35
Sodium nitrate . .	36 - 40
Charcoal . . . .	1.5 - 2.5
Diphenylamine . .	0.5 - 1.5
Heavy hydrocarbons	0.5 - 1.5

*Properties:* Grayish-black color. Consistency of brown sugar, due to small amount of mineral oil. Less sensitive than nitrostarch.

*Uses:* Was used in World War I as bursting charge for hand grenades, rifle grenades, and trench-mortar shells.

See Nitrostarch.

## TROTYL

British name for Trinitrotoluene (See).

## UROTROPINE

See Hexamethylene Tetramine, Phenate Hexamine.

## U. S. NU-GEL

A brand of gelatinous permissible explosives manufactured by United States Powder Co., Terre Haute, Ind.

See Permissible Explosives.

## U. S., U. S. SPECIAL

Brands of nongelatinous permissible explosives manufactured by United States Powder Co., Terre Haute, Ind.

See Permissible Explosives.

## VASELINE

Trade mark for a brand of Mineral Jelly (See).

## VESICANTS (FLESH-INJURANTS) (BLISTER-PRODUCERS)

Chemical agents which are readily absorbed, followed by inflammation, burns, and the destruction of tissue. See Vinylchlorarsine, Dichlorethyl Sulfide, Ethyldichlorarsine.

## VINCENNITE

*Composition:*

	PER CENT
Hydrogen cyanide.	. 50
Arsenic trichloride	. 30
Tin tetrachloride .	. 15
Chloroform. . .	. 5

*Uses:* Used by French in World War I in chemical shells. Difficult to obtain toxic concentrations, on account of the extreme volatility of the hydrocyanic acid.

See Hydrocyanic Acid.

## VITRITE

French name for Cyanogen Chloride (See).

## VOMITING GAS

See Chlorpicrin.

## WAR GASES

See Lacrimators, Lung Irritants, Systemic Poisons, Vesicants.

## WASHING SODA (SAL SODA)

*Composition:*  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$

*Properties:* Colorless crystals. Effloresces on exposure to air.

*Uses:* In gas-protection pads.

See Sodium Thiosulfate.

## WATER-GAS TAR

*Properties:* Viscid, dark-brown liquid. Sp. gr. 1.0–1.15.

*Uses:* For compositions used in flame projectors.

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**WESCO COAL POWDER**

A brand of nongelatinous permissible explosives manufactured by West Coast Powder Co., Everett, Wash. See Permissible Explosives.

**WETTER-ASTRALIT**

A German Permissible Explosive.

*Composition:*

	PER CENT
Gelatinized nitroglycerine . . .	12.0
Ammonium nitrate . . . . .	57.0
Wood meal . . . . .	2.0
Coal powder . . . . .	2.0
Common salt . . . . .	27.0

**WHITE PHOSPHORUS**

See Phosphorus (White).

**WOOD CHARCOAL**

See Charcoal.

**WOOD MEAL (WOOD FLOUR)**

A fine powder, made from sawdust or wood waste, which absorbs liquids readily.

*Uses:* As absorbent for nitroglycerine in dynamites and permissible explosives.

**WOOD PULP**

White fibrous material used as absorbent for nitroglycerine in the manufacture of dynamite.

**WP**

Chemical Warfare symbol for White Phosphorus. See Phosphorus White.

**YELLOW CROSS**

German name for Ethyldichlorarsine (See).

**YPERITE**

French name for Dichlorethyl Sulfide (See).

**ZINC DUST**

*Symbol:* Zn

*Properties:* Bluish-white powder. Sp. gr. 7.14 at 20°. M. P. 419.4°. B. P. 907°.

*Uses:* To produce a dense white or gray smoke by burning it in combination with hexachlorethane. For a grayer smoke, naphthalene or anthracene is added to the mixture.

See HC Mixture.

**ZIRCONIUM**

*Symbol:* Zr

*Properties:* Hard, lustrous, grayish, crystalline scales. Sp. gr. 6.5. M. P. about 1800°.

*Uses:* In finely divided form as oxygen-acceptor in priming mixtures, P<sup>30</sup>. In fuze heads in combination with lead styphnate, P<sup>31</sup>.

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